



CITY OF
WARREN
—OHIO—

DEPARTMENT OF UTILITY SERVICES
Contract Documents and Specifications for the Construction of

BOOSTER PUMP STATION

VOLUME 2 TECHNICAL SPECIFICATIONS

STANTEC
MAY 2024



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Project Number: 173410802
Project Title: CITY OF WARREN BOOSTER PUMP STATION
Issue Date: MAY 2024
Submittal Phase: Issued for Bid

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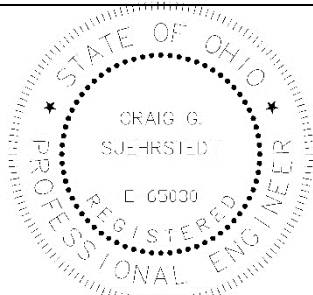
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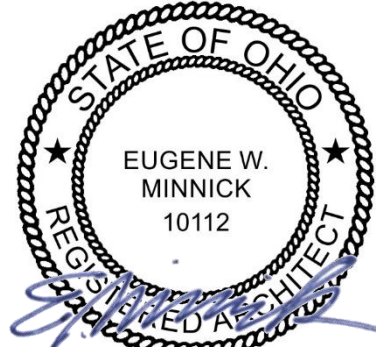
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**CITY OF WARREN
BOOSTER PUMP STATION PROJECT**

PROJECT CERTIFICATIONS



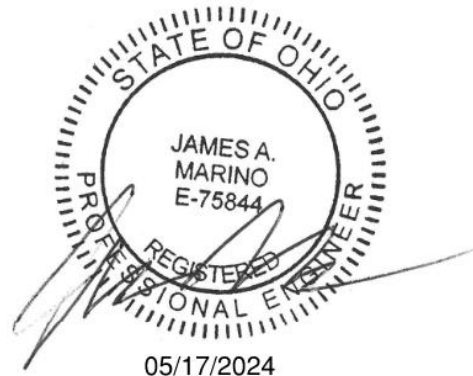
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Civil Lead
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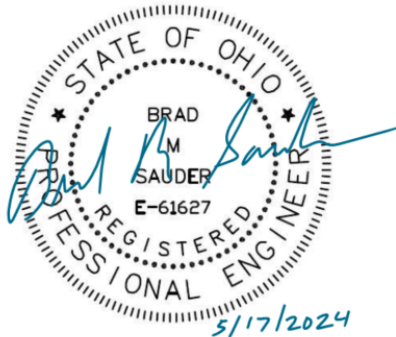
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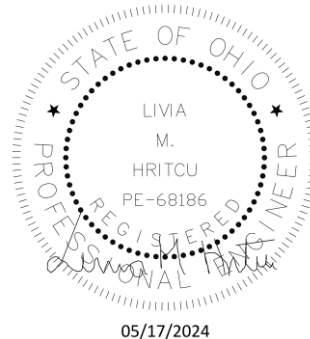
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Instrumentation & Controls



Livia Hritcu, P.E.
Electrical

SECTION 01 10 00– SUMMARY OF WORK

PART 1 -- GENERAL

1.01 THE SUMMARY

- A. The Work to be performed under this Contract shall consist of furnishing plant, tools, equipment, materials, supplies, and manufactured articles, and furnishing all labor, transportation, and services, including fuel, power, water, and essential communications, and performing all work or other operations required for the fulfillment of the Contract in strict accordance with the Contract Documents. The Work shall be complete, and all work, materials, and services not expressly indicated or called for in the Contract Documents which may be necessary for the complete and proper construction of the Work in good faith shall be provided by the Contractor as though originally so indicated, at no increase in cost to the Owner.

1.02 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

- A. Reference Specifications

01 33 00	Submittal Procedures
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1.03 WORK COVERED BY CONTRACT DOCUMENTS

- A. Mobilization
- B. Develop Stormwater Pollution Prevention Plan (SWP3)
- C. Miscellaneous clearing, grubbing and site preparation
- D. Construction of a booster pump station which generally includes but is not limited to the following:
1. Concrete foundations and concrete floors
 2. A pre-engineered metal building and interior walls.
 3. Installation of three horizontal split-case centrifugal pumps to be provided by others
 4. Installation of standby generator, electrical switchgear and variable frequency drives (VFDs) to be provided by others.
 5. Valves, piping and appurtenances
 6. Procurement and installation of a surge tank
 7. A 3-ton workstation crane
 8. Plumbing and HVAC work
 9. Electrical, instrumentation and controls work associated with the booster pump station

SUMMARY OF WORK

- E. Site security including cameras and fencing
- F. Site restoration including pavement, seeding and sodding
- G. System testing, pipeline disinfection and commissioning
- H. Demobilization

1.04 CONTRACT METHOD

- A. The Work hereunder will be constructed under a single lump sum contract.

1.05 WORK BY OTHERS

- A. Where 2 or more contracts are being performed at one time on the same Site or adjacent land in such manner that work under one contract may interfere with work under another, the Owner will determine the sequence and order of the Work in either or both contracts. When the Site of one contract is the necessary or convenient means of access for performance of work under another, the Owner may grant privilege of access or other reasonable privilege to the contractor so desiring, to the extent, amount, and in manner and at time that the Owner may determine. No Owner determination of method or time or sequence or order of the work or access privilege shall be the basis for a claim for delay or damage except under provisions of the General Conditions for temporary suspensions of the work. The Contractor shall conduct its operations so as to cause a minimum of interference with the work of such other contractors and shall cooperate fully with such contractors to allow continued safe access to their respective portions of the Site, as required to perform work under their respective contracts.
- B. The Contractor shall coordinate with the PUMP SUPPLIER, VFD SUPPLIER and GENERATOR SUPPLIER, collectively referred to as SUPPLIERS. Coordination shall include:
 - 1. The CONTRACTOR will be responsible for the coordination of the delivery of the equipment by the SUPPLIERS to the project site or project storage location, unloading of the equipment at the project site or project storage location, co-inspection of the equipment upon arrival at the site, notification to the PUMP SUPPLIER of any missing or damaged equipment, storage of the equipment on site until the time of installation, and installing the equipment according to the Contract Documents and the instructions of the SUPPLIERS.
 - 2. At the time of arrival to the delivery site, the CONTRACTOR, along with the PURCHASER, OWNER, ENGINEER and the SUPPLIERS, shall visually inspect the equipment and note in writing any apparent damage, missing equipment, defects or other deficiencies. All parties shall sign a form indicating the equipment provided to the CONTRACTOR, the date and time of acceptance, any visual defects observed, and the names and signatures of all individuals inspecting and providing/receiving the materials. Any equipment identified as missing or damaged during the inspection shall be furnished and/or replaced by the SUPPLIERS.

3. The CONTRACTOR will accept and unload the equipment and assume responsibility of the equipment following inspection and signing and will be responsible for properly unloading, storing, and securing the equipment to prevent damage or theft. Handling, and storage will conform to the SUPPLIERS' written recommendations.
 4. The CONTRACTOR will protect and maintain the equipment furnished by the SUPPLIERS in a manner that will prevent damage in accordance with the SUPPLIERS' instructions and recommendations until final acceptance of the WORK.
- C. The Contractor will need to interface and coordinate with the selected Contractor for the Finished Water Transmission Main Project, who will be responsible for the installation of the 7 miles of 24-inch discharge piping from the Booster Pump Station site location. Pipe connection, disinfection testing and commissioning will need to be coordinated between the two work packages.
- D. Interference With Work On Utilities: The Contractor shall cooperate fully with all utility forces of the Owner or forces of other public or private agencies engaged in the relocation, altering, or otherwise rearranging of any facilities which interfere with the progress of the Work, and shall schedule the Work so as to minimize interference with said relocation, altering, or other rearranging of facilities.

1.06 WORK SEQUENCE

- A. Access to the site is limited to the hours of 7:00 AM to 5:00 PM, unless approved by OWNER or otherwise limited by the local authorities.

1.07 CONTRACTOR USE OF SITE

- A. The Contractor's use of the Site shall be limited to its construction operations, including on-Site storage of materials, on-Site fabrication facilities, and field offices.

1.08 OUTAGE PLAN AND REQUESTS

- A. Unless the Contract Documents indicate otherwise, the Contractor shall not remove from service, de-energize, or modify settings for any existing operating tank pipeline, valve, channel, equipment, structure, road, or any other facility without permission from the ENGINEER and OWNER.
1. The maximum duration of any outage shall be 8 hours.
 2. The minimum time between outages shall be 72 hours.
- B. Where the Work requires modifications to existing facilities or construction of new facilities and connection of new facilities to existing facilities, the Contractor shall submit a detailed outage plan and schedule for the Engineer's approval a minimum of 2 weeks in advance of the time that such outage is planned.

- C. A completed System Outage Request form (blank furnished by the Engineer) shall accompany each outage plan. The outage plans shall be coordinated with the construction schedule and shall meet the restrictions and conditions of the Contract Documents. The outage plan shall describe the Contractor's method for preventing bypassing of other treatment units; the length of time required to complete said operation; any necessary temporary power, controls, instrumentation or alarms required to maintain control, monitoring, and alarms for the treatment plant processes; and the manpower, plant, and equipment which the Contractor will furnish for proper operation of associated treatment units. All costs for preparing and implementing the outage plans shall be at no increase in cost to the Owner.
- D. The Engineer shall be notified in writing at least one week in advance of the required outage if the schedule for performing the work has changed or if revisions to the outage plan are required.
- E. The Contractor shall provide written confirmation of the shutdown date and time 2 working days prior to the actual shutdown.

1.09 PROJECT MEETINGS

A. Preconstruction Conference

- 1. Prior to the commencement of Work at the Site, a preconstruction conference will be held at a mutually agreed time and place. The conference shall be attended by the Contractor's Project Manager, its superintendent, and its subcontractors as the Contractor deems appropriate. Other attendees will be:
 - a. Engineer and the Resident Project Representative.
 - b. Representatives of Owner.
 - c. Governmental representatives as appropriate.
 - d. Others as requested by Contractor, Owner, or Engineer.
 - e. The Contractor shall bring the preconstruction conference submittals in accordance with Section 01 33 00 – Submittal Procedures.
- 2. The purpose of the conference is to designate responsible personnel and establish a working relationship. Matters requiring coordination will be discussed and procedures for handling such matters established. The complete agenda will be furnished to the Contractor prior to the meeting date. However, the Contractor should be prepared to discuss all of the items listed below.
 - a. Status of Contractor's insurance and bonds.
 - b. Contractor's tentative schedules.
 - c. Transmittal, review, and distribution of Contractor's submittals.
 - d. Processing applications for payment.

- e. Maintaining record documents.
 - f. Critical work sequencing.
 - g. Field decisions and Change Orders.
 - h. Use of Site, office and storage areas, security, housekeeping, and Owner's needs.
 - i. Major equipment deliveries and priorities.
 - j. Contractor's assignments for safety and first aid.
 - k. Daily Report Form which the Engineer will furnish.
 - l. Submittal Transmittal Form which the Engineer will furnish.
- 3. The Engineer Owner will preside at the preconstruction conference and will arrange for keeping and distributing the minutes to all persons in attendance.
 - 4. The Contractor and its subcontractors should plan on the conference taking no less than 1 full working days. The first day will cover the items listed in paragraphs 2 and 3, and the following day(s) will be spent on reviewing the Drawings and Specifications, in extensive detail, with the Engineer and the Owner.

B. Progress Meetings

- 1. The Engineer will schedule and hold regular on-Site progress meetings at least bi-weekly and at other times as requested by Contractor or as required by progress of the Work. The Contractor, Engineer, and all subcontractors active on the Site shall attend each meeting. Contractor may at its discretion request attendance by representatives of its suppliers, manufacturers, and other subcontractors.
- 2. The Engineer will preside at the progress meetings and will arrange for keeping and distributing the minutes. The purpose of the meetings is to review the progress of the Work, maintain coordination of efforts, discuss changes in scheduling, and resolve other problems which may develop. During each meeting, the Contractor shall present any issues that may impact its progress with a view to resolve these issues expeditiously.

PART 2 -- PRODUCTS (NOT USED)

PART 3 -- EXECUTION (NOT USED)

END OF SECTION

SECTION 01 14 00– CONSTRUCTION RESTRAINTS

PART 1 -- GENERAL

1.01 THE SUMMARY

- A. Work shall be scheduled, sequenced, and performed in a manner which minimizes disruption to the operation and maintenance of existing facilities, utilities and roadways.
- B. The Contractor shall incorporate the construction and schedule constraints of this Section in preparing the construction schedules required under Section 01 32 14– Construction Schedule.

1.02 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

- A. Reference Specifications

01 32 16	Construction Progress Schedule
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1.03 EXISTING DISTRIBUTION SYSTEM

- A. The Work shall be executed while the existing water distribution system is in operation. Operation of the existing distribution system shall not be jeopardized nor shall the water quality be reduced as a result of the execution of the Work.
- B. Unless indicated otherwise, temporary pumping, piping, power, lighting, controls, instrumentation, alarms, security devices, and safety devices shall be provided by the Contractor whenever its activity or interruption due to its activity affects the existing facility.
- C. The construction constraints in this Section do not include every item affecting the completion of the Work but are intended to describe the sequence of critical events necessary to minimize disruption to the distribution system. It shall be understood and agreed by the Contractor that the critical events described are not inclusive and that additional items of Work not included may be required to minimize disruption and ensure compliance. Deviation from or modification of these suggested sequences is permitted if techniques and methods known to the Contractor will result in reducing disruption to the distribution system operation and maintaining flow, and if deviation is approved in advance by the Engineer.

1.04 BYPASSING

- A. Bypassing of untreated or partially treated water to plant effluent or any potable water outlet is prohibited during construction. In the event accidental bypassing is caused by the Contractor's operations, the Owner shall immediately be entitled to employ others to stop the bypassing and costs incurred therefore will be deducted from the Contractor's construction progress payments.

1.05 OUTAGE REQUESTS

- A. Outage requests shall be permitted with prior approval from Owner.

- B. The Contractor shall **NOT** damage or interfere with the continuous flow of traffic on Highland Avenue or Dover Avenue.
- C. The existing distribution system shall **NOT** be shut down at any time. Coordination between the Owner, Contractor and connected facilities is necessary to make this connection.
- D. The outage plans shall be submitted to the Engineer for acceptance a minimum of 2 weeks in advance of the time that such outages are required. The outage plans shall be coordinated with the construction schedule and shall meet the restrictions and conditions of this Section. The outage plan shall describe the Contractor's method for preventing bypassing of other treatment units; the length of time required to complete the operation; any necessary temporary power, controls, instrumentation, or alarms required to maintain control, monitoring, and alarms for the treatment plant processes; and the manpower, plant, and equipment which the Contractor shall provide in order to ensure proper operation of associated treatment units. Costs for preparing and implementing the outage plans shall be the responsibility of the Contractor as part of the Work.
- E. The Contractor shall not begin an alteration affecting existing facilities until specific written approval has been granted by the Engineer in each case.
- F. The Engineer will coordinate the Contractor's planned procedure with the treatment facility personnel. The Engineer has the authority to modify any proposed shutdown procedures if such procedures would adversely impact the plant operations.
- G. The Engineer shall be notified in writing at least one week in advance of the required outage if the schedule for performing the Work has changed or if revisions to the outage plan are required. The Contractor shall provide written confirmation of the shutdown date and time 2 Days prior to the actual shutdown.

1.06 TEMPORARY CONNECTIONS

- A. Making connections to existing facilities or other operations that interfere with the operation of the existing equipment shall be thoroughly planned in advance, and required equipment, materials, and labor shall be on hand at the time of undertaking the connections. Work shall be completed as quickly as possible and with as little delay as possible and shall proceed continuously (24 hours a day and seven days a week) if necessary to complete modifications and/or connections in the minimum time.
- B. The cost of any temporary facilities and night, weekend, or holiday activity and overtime payments required during process interruptions shall be included in the Work.
- C. Temporary facilities and piping shall be located to minimize interference with Contractor's construction facilities and Owner's operation and maintenance of the water treatment plant. Unless otherwise indicated, each temporary pipeline shall be of the same size as its connection to the existing or permanent facility at the downstream end of the pipeline. Piping materials shall be suitable for the material being conveyed and be as required in the Contract Specifications.

- D. When temporary electrical power, controls, instrumentation, or alarms are required for routine continuous operations of existing or new equipment, the Contractor shall provide the necessary equipment and appurtenances. Prior to installing said equipment and appurtenances, Contractor shall furnish a submittal on the proposed components and installation for Engineer's review and approval.
- E. A plan showing the size and location of the temporary facilities and piping shall be submitted to the Engineer at the same time as the outage plan required under this Section. Costs for design, provision, operation, and removal of temporary facilities and piping shall be part of the Work.

1.07 CONSTRUCTION SEQUENCING

- A. Construction activities shall be scheduled and sequenced to ensure continuous operation of the existing treatment facilities. The Contractor's scheduling shall develop construction sequencing so that the Work will not adversely impact treatment and distribution. The Contractor shall be responsible for development of the construction sequencing. In implementing the construction sequencing, the Contractor shall maintain the existing facilities in service until new facilities are constructed and are operational to supplement the existing capacity. When new facilities are operational, the existing facilities may be taken out of service. The following general guidelines shall be used by the Contractor in planning the sequence of construction.
 - 1. Safe working conditions for personnel shall be maintained during rehabilitation, modification, and demolition Work. The foregoing includes at least proper trench excavation, the provision of temporary equipment guards, supports, warning signs, walkways, covers over openings, handrailing, and protection of electrical equipment and power supply.
 - 2. Temporary facilities shall be constructed in accordance with applicable codes and regulations to operate safely and properly.
 - 3. Valves to be temporarily shut off during the Work shall be tagged as such and shall be wired shut with a crimped lead seal and padlocked.
 - 4. Electrical and mechanical equipment shall be similarly shut down.

1.08 PERMITS

- A. The Contractor shall abide by the conditions of permits and shall obtain proof of satisfaction of conditions from issuers of permits prior to acceptance of the Work by the Owner.

1.09 TIME OF COMPLETION

- A. The CONTRACTOR shall complete all work activities included in this contract as defined in the General Conditions to the Agreement between the Owner and The Contractor based on the Time of Completion Table shown below:

Milestone	Date of Milestone
Substantial Completion	July 1, 2025

CONSTRUCTION RESTRAINTS

Final Completion	October 1, 2025
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1.10 SCHEDULE CONSTRAINTS

- A. General: It is the Contractor's responsibility to coordinate and plan the construction activities to integrate each schedule constraint into performance of the overall Work.
- B. The listing of schedule constraints below does not mean that every constraint or special condition has been identified. The list does not substitute for the Contractor's coordination and planning for completion of the Work within the Contract Times.
- C. The following constraints affect the construction schedule.
 - 1. The CONTRACTOR shall perform work in a continuous manner at the project site. Abandoning the site and re-mobilizing at a later date will not be permitted without permission from the OWNER.
 - 2. Operation of the water distribution system shall be maintained at all times.
 - 3. Temporary Piping, Structural and Electrical Support Systems:
 - a. All temporary electrical materials, supports, and routings shall be submitted for approval prior to installation.
 - b. CONTRACTOR shall provide necessary temporary structural support.
 - 4. The CONTRACTOR shall not perform placement of the concrete foundation of the Booster Pump Station until the submittal of the Pre-Engineered Metal Building System has reached approval. The Contractor shall coordinate placement of anchors required for the Pre-Engineered Metal Building.
 - 5. Critical equipment submittals shall be submitted to the Owner and Engineer for review within 3-weeks of notice to proceed to expedite schedule and mitigate delays due to equipment procurement. The following items are considered to be critical submittals:
 - a. Surge Tank
 - b. Valves

PART 2 -- PRODUCTS (NOT USED)

PART 3 -- EXECUTION (NOT USED)

END OF SECTION

SECTION 01 25 00– MEASUREMENT AND PAYMENT

PART 1 -- GENERAL

1.01 THE SUMMARY

- A. Payment for the various items of the Bid Schedule, as further specified herein, shall include all compensation to be received by the CONTRACTOR for furnishing all tools, equipment, supplies, and manufactured articles, and for all labor, operations, and incidentals appurtenant to the items of work being described, as necessary to complete the various items of the WORK all in accordance with the requirements of the Contract Documents, including all appurtenances thereto, and including all costs of permits and cost of compliance with the regulations of public agencies having jurisdiction, including Safety and Health Requirements of the Occupational Safety and Health Administration of the U.S. Department of Labor (OSHA). No separate payment will be made for any item that is not specifically set forth in the Bid Schedule, and all costs therefor shall be included in the prices named in the Bid Schedule for the various appurtenant items of work.

1.02 Division 01 THROUGH 46 (Bid Item No. 01)

- A. The lump sum price stipulated for Bid Item 01: DIVISION 01 THROUGH 46 shall be in full compensation for the providing of all labor, equipment, materials, and superintendence necessary for the proper completion of all work specified. This bid Item shall include all accessory and appurtenant materials; drawings, tools, samples, material, labor and equipment necessary to complete the work as specified, shown on the Contract Drawings, or required for the proper completion of the installation, not including the work specified for BID ITEMS 02 through 03:

1. DIVISION 1 – GENERAL REQUIREMENTS

- a. The lump sum price stipulated for Division 1 - General Requirements shall exclude Mobilization and exclude Commissioning but shall include all of the work necessary to comply with the requirements of the Division 1 specifications and any other requirements of the Contract Documents not addressed by other bid items.

2. DIVISION 2 – EXISTING CONDITIONS

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MEASUREMENT AND PAYMENT

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22. DIVISION 43 – PROCESS GAS AND LIQUID HANDLING, PURIFICATION, AND STORAGE EQUIPMENT
23. DIVISION 46 – WATER AND WASTEWATER EQUIPMENT

- B. Payment for the Lump Sum item will be based on the approved schedule of values and will be paid on a percent completion basis.

1.03 MOBILIZATION AND DEMOBILIZATION (Bid Item No. 02)

- A. The lump sum price allocated in the Bid Tabulation for Mobilization (Limited to a maximum 3 percent of the TOTAL) shall consist of the preparatory work and operations for the assembling and setting up necessary for the project, insurance costs, storage areas, sanitary facilities, moving in of personnel and equipment, incidentals to the project site, all final site cleaning and demobilization, and any other facilities, as required by the specifications and special requirements of the contract, as well as by local or state law and regulation, including all permits required for the project (Unless called out in a specific permit allowance).
- B. Payment for the Lump Sum item will be paid based on the approved schedule of values for work done in the following categories:
 1. Initial Mobilization and Set-up of Temporary Facilities - 70% of Bid Item
 2. Submission and Acceptance Of As-Built Drawings - 10% of Bid Item
 3. Cleaning and Demobilization – 5% of Bid Item

MEASUREMENT AND PAYMENT

4. Remaining costs for Mobilization - 15% of Bid Item - To be prorated monthly through the construction duration

1.04 COMMISSIONING (Bid Item No. 3)

- A. Measurement for the lump sum price of Bid Item 03: COMMISSIONING (shall be fixed at 1% of the SUBTOTAL) shall be in full compensation for the providing of all labor, equipment, materials, and superintendence necessary for the proper completion of all work specified. This Bid Item shall include all accessory and appurtenant materials; drawings, tools, samples, material, labor and equipment necessary to complete the work as specified, shown on the Contract Drawings, or required for the proper completion of the installation).
- B. Partial payment of the lump sum item will be paid when the Certificate of Commissioning is executed based on the following categories:
 1. HVAC Equipment: 5% of Bid Item
 2. Surge Tank: 25% of Bid Item
 3. Booster Pumps: 50% of Bid Item
 4. Submission and acceptance of As-Built Documents: 20% of Bid Item

1.05 GENERAL ALLOWANCE (Bid Item No. 04)

- A. The Allowance amount stipulated for Bid Item 04 GENERAL ALLOWANCE shall be an amount of ten (10) percent of the Base Bid Amount (Bid Items 01 – 03), to be used at the discretion of the OWNER. The allowance may be used for payment of any unforeseen work items other than as specified or shown on the Contract Drawings and/or work directed by the OWNER.
- B. The allowance will be used to compensate the CONTRACTOR for all labor, materials, tolls and equipment required for this work or for any other miscellaneous work to enhance the quality of the final product as directed. Authorization for work to be performed under this allowance shall be by Work Order.
- C. The allowance will not be used to correct CONTRACTOR's errors or omissions.
- D. The CONTRACTOR will be compensated for work performed under this item in accordance with the procedures set forth in the General Terms and Conditions. At the end of the Contract, all remaining funds will be deleted from the Contract by a Change Order.

PART 2 -- PRODUCTS (NOT USED)

PART 3 -- EXECUTION (NOT USED)

END OF SECTION

MEASUREMENT AND PAYMENT

SECTION 01 29 73– SCHEDULE OF VALUES

PART 1 -- GENERAL

1.01 THE SUMMARY

- A. This Section defines the process whereby the Schedule of Values (lump sum price breakdown) shall be developed and incorporated into the cost loading function of the CPM Schedule in accordance with the requirements of Section 01 32 14 .
- B. Monthly progress payment amounts will be determined from the monthly progress updates of the CPM Schedule activities.
- C. Develop the Schedule of Values independent of but simultaneous with the development of the CPM Schedule activities and logic.

1.02 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

A. Reference Specifications

01 32 14	Barchart Construction Schedule
01 10 00	Summary of Work

1.03 PRELIMINARY SCHEDULE OF VALUES

- A. Submit a preliminary Schedule of Values for the major components of the Work at the Preconstruction Conference in accordance with the requirements of Section 01 10 00– Summary of Work.
- B. At a minimum, submit proposed values for the following major Work components:
 - 1. Mobilization;
 - 2. Site work, equipment pads, underground vaults, paving
 - 3. Piping
 - 4. Building exterior and roof
 - 5. Building interior
 - 6. Electrical and process mechanical equipment installation
 - 7. HVAC and plumbing;
 - 8. the total value of other Work not specifically included in the above items.
- C. Review and Revisions

1. The Contractor and Engineer shall meet and jointly review the preliminary Schedule of Values and make any adjustments in value allocations if, in the opinion of the Engineer, these are necessary to establish fair and reasonable allocation of values for the major Work components.
2. Front-end loading will not be accepted.
3. The Engineer may require reallocation of major Work components from items in the above listing if in the opinion of the Engineer such reallocation is necessary.
4. This review and any necessary revisions shall be completed within 15 Days from the date of Notice to Proceed.

1.04 DETAILED SCHEDULE OF VALUES

- A. Prepare and submit a detailed Schedule of Values to the Engineer within 30 Days from the date of Notice to Proceed.
- B. Base the detailed Schedule of Values on the accepted preliminary Schedule of Values for major Work components.
- C. Because the ultimate requirement is to develop a detailed Schedule of Values sufficient to determine appropriate monthly progress payment amounts through cost loading of the CPM Schedule activities, furnish a sufficiently detailed breakdown in order to meet this requirement.
- D. The Engineer will be the sole judge of acceptable numbers, details and description of values established.
- E. If, in the opinion of the Engineer, a greater number of Schedule of Values items than proposed is necessary, add the additional items so identified by the Engineer.
- F. Submit the minimum detail of breakdown of the major Work components as follows; furnish greater detail if requested by the Engineer:
 1. Mobilization: no breakdown required;
 2. Site work, equipment pads, underground vaults, paving: breakdown by pad and area.
 3. Piping: breakdown by interior/exterior
 4. Building exterior and roof: breakdown main structure and doors, trim, finishes.
 5. Building interior: breakdown for walls and doors, finishes.
 6. Electrical and process mechanical equipment installation: break down by piece of equipment
 7. HVAC and plumbing;

8. Break down pre-commissioning and commissioning based on completion milestones for each.
9. Break down other Work not specifically included in the above items, as necessary for the establishment of pay and schedule activity items.

G. Adjustments and Acceptance

1. The Contractor and Engineer shall meet and jointly review the detailed Schedule of Values within 35 Days from the date of Notice to Proceed, at which time the value allocations and extent of detail shall be reviewed in order to determine if necessary adjustments to the values are required, and to determine if sufficient detail has been proposed in order to allow acceptable cost loading of the CPM Schedule activities.
2. Make necessary adjustments to the value allocation or level of detail, and submit a revised detailed Schedule of Values within 40 Days from the date of Notice to Proceed.
3. Following acceptance of the detailed Schedule of Values, incorporate the values into the cost loading portion of the CPM Schedule.
4. Concurrently develop the CPM activities and logic with the development of the detailed Schedule of Values; however, it shall be necessary to adjust the detailed Schedule of Values to correlate to individual Schedule activities.
5. It is anticipated that instances will occur, due to the independent but simultaneous development of the Schedule of Values and the CPM Schedule activities, where interfacing these 2 documents will require changes to each document.
6. Schedule activities may need to be added to accommodate the detail of the Schedule of Values, and Schedule of Value items may need to be added to accommodate the detail of the CPM Schedule activities.
7. Where such instances arise, propose changes to the Schedule of Values and to the CPM Schedule activities in order to satisfy the CPM Schedule cost loading requirements.

1.05 CROSS-REFERENCE LISTING

- A. To assist in the correlation of the Schedule of Values and the CPM Schedule, provide a cross-reference listing to be furnished in 2 parts:
 1. In the first part, list each scheduled activity with the breakdown of the respective valued items making up the total cost of the activity; and,
 2. In the second part, list the valued item with the respective schedule activity or activities that make up the total indicated cost.

- B. In the case where a number of schedule items make up the total cost for a valued item (shown in the Schedule of Values), indicate the total cost for each Schedule of Value item.
- C. Update and submit these listings in conjunction with the CPM monthly submittals as indicated in Section 01 32 14 – Construction Schedule.
- D. Incorporate approved Change Orders reflected in the CPM Schedule into the Schedule of Values as a single unit identified by the Change Order number.

1.06 CHANGES TO SCHEDULE OF VALUES

- A. Changes to the CPM Schedule which additional activities not included in the original schedule but included in the original Work (schedule omissions) shall have values assigned as approved by the Engineer.
- B. Reduce other activity values in order to provide equal value adjustment increases for added activities, as approved by the Engineer.
- C. In the event that the Contractor and Engineer agree to make adjustments to the original Schedule of Values because of inequities discovered in the original accepted detailed Schedule of Values, increases and equal decreases to values for activities may be made.

1.07 LIQUIDATED DAMAGES

- A. The Schedule of Values information is an integral part of the scheduling and reporting under Section 01 32 14– Construction Schedule and the progress payment information.
- B. As such, it is critical information to evaluating progress and the proper planning of the Owner's and Engineer's Work related effort as well as their financial obligations associated with the Project.
- C. Accordingly, if a submittal required by this Section is found to be incomplete or is submitted later than required, the Owner will suffer financial loss and, accordingly, liquidated damages will be assessed against the Contractor in accordance with Article 4 of the Agreement.

PART 2 -- PRODUCTS (NOT USED)

PART 3 -- EXECUTION (NOT USED)

END OF SECTION

SECTION 01 32 4 – BARCHART CONSTRUCTION SCHEDULE

PART 1 -- GENERAL

1.01 THE SUMMARY

- A. The Contractor shall schedule the Work in accordance with the Contract Documents.
- B. Where submittals are indicated, submit a PDF document.
- C. The Contractor is alerted to Section 01 14 00 – Construction Restraints.

1.02 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

- A. Reference Specifications

01 14 00	Construction Restraints
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1.03 INITIAL SCHEDULE SUBMITTALS

- A. The Contractor shall submit 2 schedule documents at the Preconstruction Conference that shall serve as the Contractor's Plan of Operation for the initial 60 Day period of the Contract Times and shall identify the manner in which the Contractor intends to complete Work within the Contract Time. The Contractor shall submit a 60 Day Plan of Operation Bar Chart Schedule and a Project Overview Bar Chart Schedule for Work as indicated below.
 - 1. 60 Day Bar Chart Plan of Operation Schedule: The bar chart shall show the Contractor's early activities (mobilization, permits, submittals necessary for early material and equipment procurement, submittals necessary for long lead equipment procurement, scheduling submittals, initial site work, and other submittals required in the first 60 Days).
 - 2. Project Overview Bar Chart Schedule: The Bar Chart shall indicate the major components of the Work and the sequence relations between the major components and subdivisions of major components. The bar chart schedule shall indicate the relationships and time frames in which the various components of the Work will be made substantially complete and placed into service in order to meet the Contract Times. Sufficient detail shall be included for the identification of subdivisions of major components according to such activities as mobilization, site dewatering, excavation, demolition, yard piping installation, placement of structural backfill, final site grading, and other important Work for each major item within the overall project scope. Planned durations and start dates shall be indicated for each work item subdivision. Each major component and subdivision component shall be accurately plotted on time scale sheets not to exceed 36-inches by 60-inches in size. Not more than 4 sheets shall be employed to represent this overview information.

- B. The Engineer and the Contractor shall meet to review and discuss the 60 Day Plan of Operations and Project Overview Schedules within 5 Days after submittal. The Engineer's review and comment on the schedules will be limited to conformance to the Contract Documents. The Contractor shall make corrections to the schedules necessary to comply with requirements and shall adjust the schedules to incorporate any missing information requested by the Engineer.

1.04 CHANGE ORDERS

- A. Upon approval of a change order or upon receipt of authorization to proceed with additional Work, the change shall be depicted in the next submittal of the Project Overview Bar Chart Schedule.

1.05 STATUS REPORTING

- A. The Contractor shall furnish monthly Project Overview Bar Chart Schedules and written narrative reports in the form indicated below.
- B. The Project Overview Bar Chart Schedule shall be a summary of the current construction schedule for major project components (original and as updated and adjusted throughout the entire construction period). It shall be limited to not more than 4 pages and shall be a PDF document. The major project components shall be represented as time bars which shall be subdivided into various types of Work including dewatering, excavation, demolition, yard piping, placement of structural backfill, and final site grading.
- C. Each major component and subdivision shall be plotted accurately on a time scale consistent with the early start and finish activity information contained in the latest update of the schedule. In addition, a percent completion shall be listed for each major component and subdivision. The Contractor shall amend the Project Overview Bar Chart Schedule as necessary to include any additional detail required by the Engineer. The Contractor shall include any additional information requested by the Engineer at any time during construction.
- D. The Contractor shall prepare monthly written narrative reports of the status of the project for submission to the Engineer. Status reports shall include:
 - 1. The status of major project components (percent complete and amount of time ahead or behind schedule) and an explanation of how the project will be brought back on schedule if delays have occurred.
 - 2. The progress made on critical activities indicated on the construction schedule.
 - 3. Explanations for any lack of Work on critical activities planned to be performed during the last month.
 - 4. Explanations for any schedule changes, including changes to the logic or to activity durations.
 - 5. A list of the critical activities scheduled for the next 2 months.
 - 6. The status of major material and equipment procurements.

7. The value of materials and equipment properly stored at the Site but not yet incorporated into the Work.
8. Any delays encountered during the reporting period.
9. An assessment of inclement weather delays and impacts to the progress of the Work.
10. The Contractor may include any other information pertinent to the status of the project.
11. The Contractor shall include additional status information requested by the Engineer.

1.06 INCLEMENT WEATHER PROVISIONS OF THE SCHEDULE

- A. The construction schedule shall include lost days on the construction schedule due to inclement weather. Inclement weather delays shall be determined in accordance with Section 00 80 00 - Supplementary Conditions of the Construction Contract.

PART 2 -- PRODUCTS (NOT USED)

PART 3 -- EXECUTION (NOT USED)

END OF SECTION

SECTION 01 33 00 – SUBMITTAL PROCEDURES

PART 1 -- GENERAL

1.01 THE SUMMARY

A. Wherever submittals are required by the Contract Documents, submit them to the Engineer.

B. List of Reference Documents

01 29 73	Schedule of Values
01 32 14	Barchart Construction Schedule
01 32 16	CPM Construction Schedule
01 52 00	Field Office, Equipment, and Services
01 60 00	Products, Materials, and Equipment, and Substitutions
01 77 00	Project Closeout

C. Within 10 Days after the date of commencement as stated in the Notice to Proceed, submit the following items for review:

1. Submittal Schedule

- a. Submit a preliminary schedule of Shop Drawings, Samples, and proposed Substitutes ("or equal") submittals listed in the Bid.
- b. Base the schedule of submittals on Contractor's priority, planned construction sequence and schedule, long-lead items, and size of submittal package.
- c. Allow time for resubmittals.

2. Submit a list of permits and licenses the Contractor shall obtain, indicating the agency required to grant the permit and the expected date of submittal for the permit and required date for receipt of the permit.

1.02 PRECONSTRUCTION CONFERENCE SUBMITTALS

A. At the preconstruction conference of Section 01 10 00 – Summary of Work, submit the following items to the Engineer for review:

1. a revised schedule of Shop Drawings, Samples, and proposed Substitution ("or-equal") submittals listed in the Bid;
2. a list of permits and licenses the Contractor shall obtain, indicating the agency required to grant the permit, the expected date of submittal for the permit, and required date for receipt of the permit;
3. a preliminary schedule of values in accordance with Section 01 29 73 – Schedule of Values;

4. a 60-Day plan of operation; final cost loaded schedule to be approved within 90 days from notice to proceed;
5. a project overview bar chart;

1.03 SHOP DRAWINGS

- A. Wherever called for in the Contract Documents or where required by the Engineer, furnish one electronic copy of each Shop Drawing submittal.
- B. Shop Drawings may include detail design calculations, shop-prepared drawings, fabrication and installation drawings, erection drawings, lists, graphs, catalog sheets, data sheets, and similar items.
- C. Whenever the Contractor is required to submit design calculations as part of a submittal, such calculations shall bear the signature and seal of an engineer registered in the appropriate branch and in the state wherein the Project is located, unless otherwise indicated.
- D. Transmittal Form
 1. Shop Drawing submittals shall be accompanied by the Engineer's standard submittal transmittal form, a reproducible copy of which is available from the Engineer.
 2. A submittal without the form, or where applicable items on the form have not been completed, will be returned for resubmittal.
- E. Organization
 1. Use a single submittal transmittal form for each technical specification Section or item or class of material or equipment for which a submittal is required.
 2. A single submittal covering multiple Sections will not be accepted, unless the primary specification references other Sections for components: For example, if a pump Section references other Sections for the motor, shop-applied protective coating, anchor bolts, local control panel, and variable frequency drive, a single submittal would be accepted, whereas a single submittal covering vertical turbine pumps and horizontal split-case pumps would not be accepted.
 3. On the transmittal form, index the components of the submittal.
 4. Relate the submittal components to specification paragraph and subparagraph, Drawing number, detail number, schedule title, room number, or building name, as applicable.
 5. Unless otherwise indicated, match terminology and equipment names and numbers used in the submittals with those used in the Contract Documents.
- F. Format
 1. Submittals shall be submitted as a PDF document.

2. Number every page in a submittal in sequence.
 3. Where product data from a manufacturer is submitted, clearly mark which model is proposed, with complete pertinent data capacities, dimensions, clearances, diagrams, controls, connections, anchorage, and supports.
 4. Present a sufficient level of detail for assessment of compliance with the Contract Documents.
 5. Before accepting the number system option in the following Subparagraph, the Specifier should verify that the document tracking system to be used in the field office will function under an alphanumeric system. If not, select the second optional wording for compatibility.
 6. Numbering
 - a. Assign to each submittal a unique number according to specification section. For example, 01 10 00 – 001A for first submittal, 31 23 19 – 002A for the second submittal, and so on.
 - b. Number the submittals sequentially, with the submittal numbers clearly noted on the transmittal.
 - c. Assign original submittals a numeric submittal number followed by a letter of the alphabet in order to distinguish between the original submittal and each resubmittal: For example, if submittal "25-A" requires a resubmittal, the first resubmittal will bear the designation "25-B" and the second resubmittal will bear the designation "25-C," and so on.
- G. Disorganized submittals that do not meet the requirements of the Contract Documents will be returned without review.
- H. Engineer's Review
1. Except as otherwise indicated, the Engineer will return prints of each submittal to the Contractor with comments noted thereon, within 14 Days following receipt by the Engineer.
 2. It is considered reasonable that the Contractor shall make a complete and acceptable submittal to the Engineer by the first resubmittal on an item.
 3. The Owner reserves the right to withhold monies due to the Contractor to cover additional costs of the Engineer's review beyond the first resubmittal.
 4. The Engineer's maximum review period for each submittal or resubmittal will be 14 Days; thus, for a submittal that requires 2 resubmittals before it is complete, the maximum review period could be 42 Days.
- I. If a submittal is returned to the Contractor marked "NO EXCEPTIONS TAKEN," formal revision and resubmission will not be required.

J. If a submittal is returned marked "MAKE CORRECTIONS NOTED," the Contractor shall make the corrections on the submittal, but formal revision and resubmission will not be required.

K. Resubmittals

1. If a submittal is returned marked "AMEND-RESUBMIT," the Contractor shall revise the submittal and resubmit the required number of copies.
2. Resubmittal of portions of multi-page or multi-drawing submittals will not be accepted: For example, if a Shop Drawing submittal consisting of 10 drawings contains one drawing noted as "AMEND-RESUBMIT," the submittal as a whole is deemed "AMEND-RESUBMIT," and 10 drawings are required to be resubmitted.
3. Every change from a submittal to a resubmittal or from a resubmittal to a subsequent resubmittal shall be identified and flagged on the resubmittal.

L. Rejected Submittals

1. If a submittal is returned marked "REJECTED-RESUBMIT," it shall mean either that the proposed material or product does not satisfy the specification, the submittal is so incomplete that it cannot be reviewed, or is a substitution request not submitted in accordance with Section 01 60 00 – Products, Materials, Equipment, and Substitutions.
2. In the latter case, the Contractor shall submit the substitution request according to the requirements of Section 01 60 00 – Products, Materials, Equipment, and Substitutions.
3. The resubmittal of rejected portions of a previous submittal will not be accepted.

M. The fabrication of an item may commence only after the Engineer has reviewed the pertinent submittals and returned copies to the Contractor marked either "NO EXCEPTIONS TAKEN" or "MAKE CORRECTIONS NOTED."

N. Corrections indicated on submittals shall be considered as changes necessary to meet the requirements of the Contract Documents and shall not be taken as changes to the contract requirements.

O. Review by Contractor

1. Submittals shall be carefully reviewed by an authorized representative of the Contractor prior to submission to the Engineer.
2. Each submittal shall be dated and signed by the Contractor as being correct and in strict conformance with the Contract Documents.
3. In the case of Shop Drawings, each sheet shall be so dated and signed.
4. Any deviations from the Contract Documents shall be noted on the transmittal sheet.

5. The Engineer will only review submittals that have been so verified by the Contractor.
6. Non-verified submittals will be returned to the Contractor without action taken by the Engineer, and any delays caused thereby shall be the total responsibility of the Contractor.

P. Conformance

1. Corrections or comments made on the Contractor's Shop Drawings during review shall not relieve the Contractor from compliance with Contract Drawings and Specifications.
2. A lack of comments made on the Contractor's Shop Drawings during review shall not relieve the Contractor from compliance with Contract Drawings and Specifications.
3. Review is for conformance to the design concept and general compliance with the Contract Documents only.
4. The Contractor shall be responsible for confirming and correlating quantities and dimensions, fabrication processes and techniques, coordinating Work with the trades, and satisfactory and safe performance of the Work.

1.04 SAMPLES

A. Quantity

1. The Contractor shall submit the number of samples indicated by the Specifications.
2. If the number is not indicated, submit not less than 3 samples.
3. Where the quantity of each sample is not indicated, submit such quantity as necessary for proper examination and testing by the methods indicated.

B. Identification and Distribution

1. Individually and indelibly label or tag each sample, indicating the salient physical characteristics and the manufacturer's name.
2. Upon acceptance by the Engineer, one set of the samples will be stamped and dated by the Engineer and returned to the Contractor, and one set of samples will be retained by the Engineer until completion of the Work.

C. Selection

1. Unless otherwise indicated, the Engineer will select colors and textures from the manufacturer's standard colors and standard materials, products, or equipment lines.
2. If certain samples represent non-standard colors, materials, products, or equipment lines that will require an increase in Contract Times or Price, the Contractor shall clearly state so on the transmittal page of the submittal.

SUBMITTAL PROCEDURES

D. The Contractor shall schedule sample submittals such that:

1. Sample submittals for color and texture selection are complete so the Engineer has 45 Days to assemble color panels and select color- and texture-dependent products and materials without delay to the construction schedule; and,
2. After the Engineer selects colors and textures, the Contractor has sufficient time to provide the products or materials without delay to the construction schedule.
3. The Contract Times will not be extended for the Contractor's failure to allow enough review and approval or selection time, failure to submit complete samples requiring color or texture selection, or failure to submit complete or approvable samples.

1.05 TECHNICAL MANUAL

- A. The Contractor shall submit technical operation and maintenance information for each item of mechanical, electrical, and instrumentation equipment in an organized manner in the Technical Manual.
- B. The manual shall be written such that it can be used and understood by the Owner's operation and maintenance staff.
- C. The Specifier must consider whether the organization of information in the manuals is appropriate for the scope of the Work. If possible during customization, discuss the manual organization with Owner staff and O&M manual specialists.

D. Categories

1. The Technical Manual shall be subdivided first by Specification Section number; second, by equipment item; and last, by "Category." The following "Categories" shall be addressed (as applicable):

a. Category 1 - Equipment Summary

- 1) Summary: A table shall indicate the equipment name, equipment number, and process area in which the equipment is installed.
- 2) Form: The Engineer will supply an Equipment Summary Form for each item of mechanical, electrical, and instrumentation equipment in the Work. The Contractor shall fill in the relevant information on the form and include it in Part 1.

b. Category 2 - Operational Procedures

- 1) Procedures: Manufacturer-recommended procedures on the following shall be included in Part 2:
 - a) Installation
 - b) Adjustment
 - c) Startup

- d) Location of controls, special tools, equipment required, or related instrumentation needed for operation
 - e) Operation procedures
 - f) Load changes
 - g) Calibration
 - h) Shutdown
 - i) Troubleshooting
 - j) Disassembly
 - k) Reassembly
 - l) Realignment
 - m) Testing to determine performance efficiency
 - n) Tabulation of proper settings for pressure relief valves, low and high pressure switches, and other protection devices
 - o) List of all electrical relay settings including alarm and contact settings
- c. Category 3 - Preventive Maintenance Procedures
- 1) Procedures: Preventive maintenance procedures shall include manufacturer-recommended procedures to be performed on a periodic basis, both by removing and replacing the equipment or component, and by maintaining the equipment in place.
 - 2) Schedules: Recommended frequency of preventive maintenance procedures shall be included. Lubrication schedules, including lubricant SAE grade, type, and temperature ranges, shall be covered.
- d. Category 4 - Parts List
- 1) Parts List: A complete parts list shall be furnished, including a generic description and manufacturer's identification number for each part. Addresses and telephone numbers of the nearest supplier and parts warehouse shall be included.
 - 2) Drawings: Cross-sectional or exploded view drawings shall accompany the parts list. Part numbers shall appear on the drawings with arrows to the corresponding part.
- e. Category 5 - Wiring Diagrams
- 1) Diagrams: Category 5 shall include complete internal and connection wiring diagrams for electrical equipment items.

f. Category 6 - Shop Drawings

- 1) Drawings: This category includes approved shop or fabrication drawings with Engineer comments and corrections incorporated, complete with dimensions.

g. Category 7 - Safety

- 1) Procedures: This category describes the safety precautions to be taken when operating and maintaining the equipment or working near it.

h. Category 8 - Documentation:

- 1) Equipment warranties, affidavits, certifications, calibrations, laboratory test results, etc. required by the Technical Specifications shall be placed in this category.

E. Format

1. Bind each Technical Manual in standard size 3-ring hardcover binders, labeled on the spine and cover with Project name, Owner's project number, Specification Section number, equipment name, and equipment identification number
2. Each Binder shall contain its own detailed table of contents at the front, plus a summary level table of contents information for the other binders in a multi-binder set.
3. Documents in binders shall be 3-hole punched, with no text punched out, and pages larger than 8-1/2 by 11 shall be folded to 8-1/2 by 11 size.
4. Provide a USB Flash Drive with electronic files with each final set of Technical Manuals, as follows:
 - a. Project-specific files created in the latest version of Microsoft Word;
 - b. AutoCAD, version 2013;
 - c. Adobe Acrobat portable document format (PDF) or other software required by the Specifications; and,
 - d. Manufacturer literature in Adobe Acrobat portable document format (PDF).

F. Review Process

1. Furnish 1 electronic deliverable of the draft Technical Manuals for each Specification Section that requires a manual.
2. The Engineer will retain one copy, will forward one copy to the Owner, and will return one copy to the Contractor with review comments.
3. Incorporate comments into the draft and submit 1 copy of the final manual for acceptance.

G. Schedule

H. Submittal and Corrections

1. Except as otherwise indicated, submit the manuals in final form to the Engineer not later than three (3) months before start-up of equipment.
 2. Discrepancies found by the Engineer shall be corrected within 30 Days from the Date of written notification by the Engineer.
- I. Manuals that are incomplete or unacceptable at the schedule criterion above will constitute sufficient justification for the Owner to retain the amount in Paragraph "Technical Manual Submittals" of Section 01 77 00 – Project Closeout, from any monies due the Contractor.
- J. If the parts list would be the same as the spare parts list on the Project, Paragraph 1.6A could be incorporated into Category 4 of the Technical Manual, above.

1.06 SPARE PARTS LIST

A. General

1. Furnish to the Engineer 1 electronic deliverable of the spare parts information for mechanical, electrical, and instrumentation equipment.
2. The spare parts list shall include those spare parts that each manufacturer recommends to be maintained by the Owner in inventory.

B. Sources and Pricing

1. The spare parts list shall include a current list price of each spare part.
2. Each manufacturer or supplier shall indicate the name, address, and telephone number of its nearest outlet of spare parts, to assist the Owner in ordering.

C. Format

1. Cross-reference the spare parts lists to the equipment numbers designated in the Contract Documents.
2. The spare parts lists shall be PDF electronic format.

1.07 AS-BUILT DRAWINGS

A. On-Site Drawings Set

1. Maintain one set of Drawings at the Site for the preparation of as-built drawings.
2. On this set, mark every project condition, location, configuration, and any other change or deviation which may differ from the Contract Drawings at the time of award, including buried or concealed construction and utility features that are revealed during the course of construction.

3. Give special attention to recording the horizontal and vertical location of buried utilities that differ from the locations indicated, or that were not indicated on the Contract Drawings.
4. Supplement the as-built drawings by any detailed sketches as necessary or as directed, in order to fully indicate the Work as actually constructed.
5. The as-built drawings are the Contractor's representation of as-built conditions, shall include revisions made by addenda and change orders, and shall be maintained up-to-date during the progress of the Work.
6. Use red font for alterations and notes.
7. Notes shall identify relevant Change Orders by number and date.

B. Submittal

1. Submit paper copies of the as-built drawings on the 20th Day of every third month after the month in which the Notice to Proceed is given, as well as at completion of the Work.
2. Failure to submit complete as-built drawings on or before the 20th Day will enact the liquidated damages clause for interim record drawing submittals described in Agreement.

- C. In the case of those drawings that depict the detail requirement for equipment to be assembled and wired in the factory, such as motor control centers and the like, update the as-built drawings by indicating those portions which are superseded by Change Order drawings or final Shop Drawings, and by including appropriate reference information describing the Change Orders by number and the Shop Drawings by manufacturer, drawing, and revision numbers.

D. Unacceptable Drawings

1. Disorganized or incomplete as-built drawings will not be accepted.
2. The Contractor shall revise them and resubmit within 10 Days.

- E. As-built drawings shall be accessible to the Engineer during the construction period.

F. Final Payment

1. Final payment will not be acted upon until the as-built drawings have been completed and approved by the Engineer.
2. Up-to-date as-built drawings shall be in the form of a set of prints with carefully plotted information overlaid in AutoCAD Version 2013.

- G. Information submitted by the Contractor will be assumed to be correct, and the Contractor shall be responsible for the accuracy of such information.

1.08 QUALITY CONTROL (QC) SUBMITTALS

- A. Quality control submittals are defined as those required by the Specifications to present documentary evidence to the Engineer that the Contractor has satisfied certain requirements of the Contract Documents.
- B. Unless otherwise indicated, QC submittals shall be submitted:
 - 1. Before delivery and unloading, for the following types of submittals:
 - a. Manufacturers' installation instructions
 - b. Manufacturers' and Installers' experience qualifications
 - c. Ready mix concrete delivery tickets
 - d. Design calculations
 - e. Affidavits and manufacturers' certification of compliance with indicated product requirements
 - f. Laboratory analysis results
 - g. Factory test reports
 - 2. Within 30 Days of the event documented for the following types of submittals:
 - a. Manufacturers' field representative certification of proper installation
 - b. Field measurement
 - c. Field test reports
 - d. Receipt of permit
 - e. Receipt of regulatory approval
- C. The Engineer will record the date that a QC submittal was received and review it for compliance with submittal requirements, but the review procedures above for Shop Drawings and samples will not apply.
- D. Retain the following article only if our CM forms will be used.

1.09 INFORMATIONAL SUBMITTALS

- A. Informational submittals formalize the flow of information between the Contractor and the Engineer.
- B. Electronic forms shall be obtained from the Engineer for such purpose.

1.10 CONSTRUCTION PHOTOGRAPHS

- A. General

1. Furnish construction photographs showing the progress of the Work.
2. A commercial photographer shall take digital photos at 600 DPI.
3. Provide electronic JPEG photos with the date of photographing, the project title, a short description of what is in the photograph, and the direction the camera is facing.

B. Prints and Negatives

1. Starting when the Work begins and continuing for as long as the Work is in progress, take not less than 15 images at intervals not more than 1 week apart, consisting of different subjects or angles or view at different locations of progress on the Site.
2. Furnish to the Engineer within 1 week after the date photos are taken.
3. The JPEG photos shall become sole property of the Owner upon submittal by the Contractor.

C. Additional Photographs

1. Upon completion of the Work but before final payment, an additional 20 electronic images, including at least 6 aerial images, at 600DPI, shall be made of the Work as requested by the Engineer.
2. Submit JPEG images to the Engineer for transmittal to the Owner.

PART 2 -- PRODUCTS (NOT USED)

PART 3 -- EXECUTION (NOT USED)

END OF SECTION

SECTION 01 33 17 – STRUCTURAL DESIGN, SUPPORT AND ANCHORAGE

PART 1 -- GENERAL

1.01 SUMMARY

- A. The Contractor shall provide calculations and details for structural and non-structural components, supports, and anchorages as required by the Contract Documents and the 2024 Ohio Building Code (OBC). The Contractor shall furnish and install all such structural and non-structural components, supports, and anchorages in accordance with the calculations and details.
- B. The Contractor shall provide calculations and details for structures and non-building structures, supports, and anchorages as required by the Contract Documents and the 2024 OBC. The Contractor shall furnish and install all such structures and non-building structures, supports, and anchorages in accordance with the calculations and details.
- C. Where a conflict exists between the requirements of the Contract Documents and the 2024 OBC, the more stringent requirement shall apply.
- D. Design parameters used to determine Seismic and Wind design forces shall be as listed herein.

1.02 REFERENCE SPECIFICATIONS, CODES AND STANDARDS

A. Reference Specifications

01 33 00	Submittal Procedures
03 60 00	Grouting
05 50 00	Metal Fabrications
04 05 19.16	Masonry Anchors
05 05 19	Post Installed Concrete Anchors

- B. The edition of the standards applicable to the Work shall be those editions referenced by the 2024 OBC. If the standard is not referenced by the OBC, nor an OBC-referenced standard listed below, the edition of the standard applicable to the Work shall be the edition in effect on the date of signing and sealing of the contract specifications.

Building Code	
OBC	2024 Ohio Building Code
American Society of Civil Engineers (ASCE)	
ASCE 7 -16	Minimum Design Loads for Buildings and Other Structures with Supplement No. 1
American Concrete Institute (ACI)	
ACI 318	Building Code Requirements for Structural Concrete
The Masonry Society (TMS)	
TMS 402	Building Code Requirements for Masonry Structures (TMS 402/ACI 530/ASCE 5)
TMS 602	Specification for Masonry Structures (TMS 602/ACI 530.1/ASCE 6)

STRUCTURAL DESIGN, SUPPORT AND ANCHORAGE

1.03 CONTRACTOR SUBMITTALS

A. Furnish submittals in accordance with Section 01 33 00 – Submittal Procedures.

1. Calculations and details are considered a Deferred Submittal as defined in the OBC.
2. Calculations and details shall be complete, accurate, and in accordance with the requirements of the OBC and ASCE 7 and shall be signed and sealed by a Professional Engineer registered in the State of Ohio.
3. Calculations shall be clear and concise and show equipment and other non-structural component anchorage forces and the capacities of the anchorage elements proposed by the Contractor. The calculations shall substantiate a complete load path from the component or equipment being anchored into the supporting structure or foundation.
4. The calculations and details shall demonstrate a complete lateral and vertical load path and shall clearly indicate all forces imposed on the supporting structure.
5. Calculations and details are required for all Non-Structural components, supports, anchorages, and attachments.
 - a. Non-Structural components shall include all architectural, mechanical, and electrical components, equipment, piping, ductwork, and all other similar or related appurtenances necessary to produce the complete architectural, mechanical, and electrical systems.
6. When the Contract Documents require the Contractor to design structures or structural components, calculations and details for those structures and structural components, and their supports, anchorages, and attachments, are required.
7. When computer generated calculations and analyses are included as part (or as the whole) of the calculations, the calculations shall include, but not be limited to, the following: derivations of all input parameters; clear indication of the applicable load combinations and building code equations; diagrams of all members, geometry, loads, forces, reactions and deflections, for all components and connections; and output results demonstrating all stress, force, deflection and other Contract Document and building code requirements have been satisfied.
8. All calculations associated with anchorage into concrete or masonry shall be done using Strength Level forces and shall be in accordance with the applicable provisions of ACI 318 and TMS 402, respectively.
9. Refer to Part 2 below for additional requirements.

1.04 SEISMIC DESIGN CRITERIA

A. Design Requirements

1. Design Parameters:
 - a. Risk Category: III
 - b. Seismic Design Category: B

- c. Mapped MCE_R , 5% damped spectral response acceleration parameter at short periods: $S_S = 0.125g$.
- d. Mapped MCE_R , 5% damped spectral response acceleration parameter at a period of 1-second: $S_1 = 0.047g$
- e. Site Class: D
- f. Design, 5% damped spectral response acceleration parameter at short periods: $S_{DS} = 0.133g$
- g. Design, 5% damped spectral response acceleration parameter at a period of 1-second: $S_{D1} = 0.075g$
- h. Long period transition period: $T_L = 12$ seconds
- i. Response modification coefficient, R : In accordance with ASCE 7, Tables 12.2-1, 12.14-1, 15.4-1 and 15.4-2.
- j. Seismic Importance Factor, I : 1.25
- k. Component amplification factor, a_p : In accordance with ASCE 7, Tables 13.5-1 and 13.6-1.
- l. Component response modification factor, R_p : In accordance with ASCE 7, Tables 13.5-1 and 13.6-1.
- m. Component importance factor, I_p :
- n. $I_p = 1.00$, unless noted otherwise herein.
 - 1) $I_p = 1.50$ if any of the following conditions apply:
 - a) The component is required to function for life-safety purposes after an earthquake, including fire sprinkler systems and egress stairways.
 - b) The component conveys, supports, or otherwise contains toxic, highly toxic, explosive, or hazardous substances.
- 2. The following components are exempted from the seismic design requirements:
 - a. Exemptions shall be as indicated in ASCE 7 Chapter 13.

1.05 WIND DESIGN CRITERIA

A. Design Requirements

- 1. Design Parameters:
 - a. Risk Category: III
 - b. Ultimate Design Wind Speed, V_{ULT} (3 Sec): 116 miles per hour
 - c. Nominal Design Wind Speed, V_{ASD} (3 Sec): 90 miles per hour
 - d. Exposure Category: B

- e. Topographic Factor, K_{zt} : 1.0

PART 2 -- PRODUCTS

2.01 GENERAL

A. Non-Structural Component Supports and Anchors

1. Unless otherwise indicated, non-structural component supports, anchors, and restrainers shall be adequately designed for all applicable static, dynamic, operational, seismic and wind loads.
 - a. Wall-mounted equipment weighing more than 250 pounds or which is within 18-inches of the floor shall be provided with fabricated steel supports. Pedestals shall be of welded steel or engineered framing support systems. If the supported equipment is a panel or cabinet or is enclosed with removable sides, the pedestal shall match the supported equipment in appearance and dimensions.
 - b. All equipment and all other non-structural components shall be supported and anchored in place by methods that satisfy the building code and the Contract Documents.
 - c. All equipment and all other non-structural components shall be supported and anchored in place by methods that satisfy the manufacturer's applicable seismic certification requirements.
2. Component attachments shall be bolted, welded, or otherwise positively fastened without consideration of frictional resistance produced by the effects of gravity.

B. Non-Building Structures

1. Non-Building Structures shall be designed in accordance with ASCE 7 Chapter 15.
2. Non-Building Structures, foundations, supports, anchors, and restrainers shall be adequately designed for all applicable static, dynamic, operational, seismic and wind loads.

C. Anchors – General

1. Anchor bolts shall be cast-in-place unless otherwise noted or approved by the Engineer.
2. Anchor bolts shall be in accordance with Section 05 50 00 – Metal Fabrication.
3. Adhesives and epoxies for post-installed anchors in concrete or masonry shall be in accordance with Section 05 05 19 - Post Installed Concrete Anchors or Section 04 05 19.16 - Masonry Anchors, respectively.
4. Grouts for anchor bolts shall be in accordance with Section 03 60 00 - Grouting.
5. The Contractor shall determine the size, type, capacity, location, and other placement requirements of anchorage elements. Anchoring methods and leveling criteria in the manufacturer's literature shall be followed. Submit methods and criteria with the calculations and details.

STRUCTURAL DESIGN, SUPPORT AND ANCHORAGE

6. Anchor bolt calculations shall clearly show that the capacity of the anchor and the capacity of the concrete that the anchor is embedded in are adequate to resist all applicable load combinations, including seismic and wind loads.
 - a. The design of anchors resisting seismic forces shall satisfy the ductility requirements stated in the OBC, ASCE 7, ACI 318, and TMS 402.
7. Reduction factors associated with edge distance, embed length, grout and base plate thickness, and bolt spacing shall all be considered and based on the actual dimensions of the concrete or masonry that resists the anchorage forces.
8. Where anchorage is required into or through equipment pads, the following requirements shall apply unless otherwise approved by the Engineer:
 - a. For tensile forces, the embed length and associated concrete failure zone shall be provided entirely within the structural slab. No portion of the equipment pad may be considered as effective in resisting tensile forces.
 - b. For shear forces, the edge distance and associated concrete failure zone shall be provided entirely within the equipment pad. No portion of the structural slab may be considered as effective in resisting shear forces.
9. Anchor bolt details shall include required bolt diameter, embed, spacing, and edge distances.
10. Where additional reinforcement is required to satisfy anchorage requirements, such reinforcement shall be included in the anchorage details, and shall be furnished and installed by the Contractor.

D. Mechanical and Electrical Equipment Foundations

1. Equipment foundations are indicated on Drawings. The Contractor, through the equipment manufacturer, shall verify the size and weight of the equipment foundation to ensure compatibility with equipment.
2. Equipment foundation dimensions shall be coordinated with the equipment base geometry and the edge distance and embed requirements of the equipment anchorage calculations.

E. Mechanical and Electrical Equipment (Housekeeping) Pads

1. General

- a. Equipment, tanks, control cabinets, enclosures, and related equipment shall be mounted on concrete equipment pads, unless otherwise indicated. The top surface of the equipment pads shall be level, unless otherwise indicated, or otherwise required by the equipment manufacturer.
- b. Equipment pads shall be sized to accommodate the bearing and anchorage requirements of the equipment, subject to the constraints listed below.
- c. Final geometry of the equipment pads shall not result in a condition that violates applicable building code provisions, including but not limited to the provisions of the National Electric Code.

2. Mechanical Equipment Pads

- a. Mechanical equipment pad heights shall be coordinated with process equipment and piping elevation requirements. Where no such elevation constraints exist, the equipment pad height shall be as shown on the drawings, or as indicated below when no specific height is provided.
 - 1) Equipment pads for mechanical equipment shall be 3.5 inches tall (maximum) at the front of the equipment.
- b. Mechanical equipment pads shall extend not more than 2 inches beyond the front, back, and sides of the equipment, except as indicated below, unless otherwise shown on the drawings.
 - 1) Where necessary to meet seismic or wind anchorage requirements, the pads may be extended beyond the 2 inch limit indicated above. The pads shall extend not more than 6 inches beyond the front, back, and sides of the equipment.

3. Electrical Equipment Pads

- a. Electrical equipment pads shall be 3.5 inches tall (maximum) at the front of the equipment.
- b. Electrical equipment pads shall extend not more than 2 inches beyond the front, back, and sides of the equipment, except as indicated below, unless otherwise shown on the drawings.
- c. Where necessary to meet seismic anchorage requirements, the pads may be extended beyond the 2 inch limit indicated above. The pads shall extend not more than 6 inches beyond the front, back, and sides of the equipment.

PART 3 -- EXECUTION (NOT USED)

END OF SECTION

SECTION 01 35 53 – SITE SECURITY

PART 1 -- GENERAL

1.01 SECURITY PROGRAM

A. The Contractor shall:

1. Protect Work from theft, vandalism, and unauthorized entry.
2. Initiate program at mobilization.
3. Maintain program throughout construction period until completion of Work.

1.02 ENTRY CONTROL

A. The Contractor shall:

1. Restrict entry of persons and vehicles into Site.
2. Allow entry only to authorized persons with proper identification.

B. The Contractor shall control the entrance of persons and vehicles to those related to the Owner's operations.

PART 2 -- PRODUCTS (NOT USED)

PART 3 -- EXECUTION (NOT USED)

END OF SECTION

SECTION 01 42 13 – ABBREVIATIONS OF INSTITUTIONS

PART 1 -- GENERAL

1.01 GENERAL

- A. Wherever in these Specifications references are made to the standards, specifications, or other published data of the various international, national, regional, or local organizations, such organizations may be referred to by their acronym or abbreviation only. As a guide to the user of the Specifications, the following acronyms or abbreviations which may appear shall have the meanings indicated herein.

1.02 ABBREVIATIONS

AA	Aluminum Association
AABC	Associated Air Balance Council
AAMA	American Architectural Manufacturers Association
AASHTO	American Association of State Highway and Transportation Officials
AATCC	American Association of Textile Chemists and Colorists
ABMA	American Bearing Manufacturer's Association – ABMA
ACGIH	American Conference of Governmental Industrial Hygienists
ACI	American Concrete Institute
AF&PA	American Forest and Paper Association
AGA	American Gas Association
AGMA	American Gear Manufacturers Association
AHA	American Hardboard Association
AHAM	Association of Home Appliance Manufacturers
AI	The Asphalt Institute
AIA	American Institute of Architects
AIHA	American Industrial Hygiene Association
AIIM	Association for Information and Image Management
AISC	American Institute of Steel Construction
AISI	American Iron and Steel Institute
AITC	American Institute of Timber Construction

ABBREVIATIONS OF INSTITUTIONS

AMA	Acoustical Material Association
AMCA	Air Movement and Control Association International, Inc
ANS	American Nuclear Society
ANSI	American National Standards Institute, Inc.
APA	The Engineered Wood Association
API	American Petroleum Institute
APWA	American Public Works Association
ARI	Air-Conditioning and Refrigeration Institute
ASA	Acoustical Society of America
ASAE	American Society of Agricultural Engineers
ASCE	American Society of Civil Engineers
ASHRAE	American Society of Heating, Refrigerating, and Air Conditioning Engineers
ASME	American Society of Mechanical Engineers
ASNT	American Society of Nondestructive Testing
ASQ	American Society for Quality
ASSE	American Society of Sanitary Engineers
ASTM	American Society for Testing and Materials
AWCI	American Wire Cloth Institute
AWI	Architectural Woodwork Institute
AWPA	American Wood Preservers Association
AWPI	American Wood Preservers Institute
AWS	American Welding Society
AWWA	American Water Works Association
BBC	Basic Building Code, Building Officials and Code Administrators International
BHMA	Builders Hardware Manufacturer's Association
CABO	Council of American Building Officials
CDA	Copper Development Association

ABBREVIATIONS OF INSTITUTIONS

CEMA	Conveyors Equipment Manufacturer's Association
CGA	Compressed Gas Association
CLFMI	Chain Link Fence Manufacturer's Institute
CLPCA	California Lathing and Plastering Contractors Association
CMAA	A division/section of the Material Handling Industry of America
CPG	Compressed Gas Association
CRSI	Concrete Reinforcing Steel Institute
DCDMA	Diamond Core Drilling Manufacturer's Association
DHI	Door and Hardware Institute
DIPRA	Ductile Iron Pipe Research Association
EI	Energy Institute
EIA	Electronic Industries Alliance
EPA	Environmental Protection Agency
ETL	Electrical Test Laboratories
FCC	Federal Communications Commission
FCI	Fluid Controls Institute
FEMA	Federal Emergency Management Association
FHWA	Federal Highway Administration
FM	Factory Mutual System
FPL	Forest Products Laboratory
HI	Hydronics Institute, Hydraulic Institute
HSWA	Federal Hazardous and Solid Waste Amendments
IAPMO	International Association of Plumbing and Mechanical Officials
IBC	International Building Code
ICBO	International Conference of Building Officials
ICC	International Code Council
ICC-ES	International Code Council Evaluation Service

ABBREVIATIONS OF INSTITUTIONS

ICCEC	Electrical Code
ICEA	Insulated Cable Engineers Association
IECC	International Energy Conservation Code
IEEE	Institute of Electrical and Electronics Engineers
IESNA	Illuminating Engineering Society of North America
IFC	International Fire Code
IFGC	International Fuel Gas Code
IMC	International Mechanical Code
IME	Institute of Makers of Explosives
IPC	International Plumbing Code, Association Connecting Electronic Industries
IRC	International Residential Code
ISA	Instrument Society of Automation
ISDI	Insulated Steel Door Institute
ISEA	Industrial Safety Equipment Association
ISO	International Organization for Standardization
ITE	Institute of Traffic Engineers
ITU-T	Telecommunications Standardization Sector of the International Telecommunications Union
LPI	Lightning Protection Institute
LRQA	Lloyd's Register Quality Assurance
MBMA	Metal Building Manufacturer's Association
MIL	Military Standards (DoD)
MPTA	Mechanical Power Transmission Association
MSS	Manufacturers Standardization Society
NAAMM	National Association of Architectural Metal Manufacturer's
NACE	National Association of Corrosion Engineers
DASMA	Door and Access Systems Manufacturers Association International
NACE	National Association of Corrosion Engineers

ABBREVIATIONS OF INSTITUTIONS

NAPF	National Association of Pipe Fabricators
NBBPVI	National Board of Boiler and Pressure Vessel Inspectors
NCCLS	National Committee for Clinical Laboratory Standards
NCMA	National Concrete Masonry Association
NEC	National Electrical Code
NEMA	National Electrical Manufacturer's Association
NESC	National Electrical Safety Code
NETA	International Electrical Testing Association
NFPA	National Fire Protection Association or National Fluid Power Association
NISO	National Information Standards Organization
NIST	National Institute of Standards and Technology
NLGI	National Lubricating Grease Institute
NRCA	National Roofing Contractors Association
NSF	National Sanitation Foundation
NWWDA	National Wood Window and Door Association
OSHA	Occupational Safety and Health Administration
PCA	Portland Cement Association
PCI	Precast/Prestressed Concrete Institute
PPI	Plastic Pipe Institute
RCRA	Resource Conservation and Recovery Act
RIS	Redwood Inspection Service, a division of the California Redwood Association, CRA
RMA	Rubber Manufacturers Association
RVIA	Recreational Vehicle Industry Association
RWMA	Resistance Welder Manufacturer's Association
SAE	Society of Automotive Engineers
SDI	Steel Door Institute, Steel Deck Institute
SMA	Screen Manufacturers Association

ABBREVIATIONS OF INSTITUTIONS

SMACNA	Sheet Metal and Air Conditioning Contractors National Association
SPFA	Steel Plate Fabricator's Association
SPIB	Southern Pine Inspection Bureau
SSBC	Southern Standard Building Code, Southern Building Code Congress
SSPC	Society for Protective Coating
SSPWC	Standard Specifications for Public Works Construction
STLE	Society of Tribologists and Lubricating Engineers
TAPPI	Technical Association of the Worldwide Pulp, Paper, and Converting Industry
TFI	The Fertilizer Institute
TIA	Telecommunications Industries Association
TPI	Truss Plate Institute
UBC	Uniform Building Code
UL	Underwriters Laboratories, Inc.
USEPA	United States of America Environmental Protection Agency
WCLIB	West Coast Lumber Inspection Bureau
WDMA	National Window and Door Manufacturers Association
WEF	Water Environment Federation
WI	Woodwork Institute
WRI	Wire Reinforcement Institute, Inc.
WWPA	Western Wood Products Association

PART 2 -- PRODUCTS (NOT USED)

PART 3 -- EXECUTION (NOT USED)

END OF SECTION

SECTION 01 42 19– REFERENCE STANDARDS

PART 1 -- GENERAL

1.01 THE SUMMARY

- A. Titles of Sections and Paragraphs: Titles and subtitles accompanying specification sections and paragraphs are for convenience and reference only and do not form a part of the Specifications.
- B. Applicable Publications: Whenever in these Specifications references are made to published specifications, codes, standards, or other requirements, it shall be understood that wherever no date is indicated, only the latest specifications, standards, or requirements of the respective issuing agencies which have been published as of the date that the Contract is advertised for Bids shall apply; except to the extent that said standards or requirements may be in conflict with applicable laws, ordinances, or governing codes. No requirements set forth in the Specifications or shown on the Drawings will be waived because of any provision of or omission from said standards or requirements.
- C. Specialists, Assignments: In certain instances, specification text requires (or implies) that specific Work is to be assigned to specialists or expert entities who must be engaged to perform that Work. Such assignments shall be recognized as special requirements over which the Contractor has no choice or option. These requirements shall not be interpreted so as to conflict with the enforcement of building codes and similar regulations governing the Work; also they are not intended to interfere with local union jurisdiction settlements and similar conventions. Such assignments are intended to establish which party or entity involved in a specific unit of Work is recognized as "expert" for the indicated construction processes or operations. Nevertheless, the final responsibility for fulfillment of the entire set of Contract requirements remains with the Contractor.

1.02 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

- A. The Contractor shall construct the Work in accordance with the Contract Documents and the referenced portions of those referenced codes, standards, and specifications.
- B. Reference Standards

International Conference of Building Officials (ICBO)	
	Uniform Building Code
Southern Building Code Congress International	
National Building Code of Building Officials and Code Administrators International (BOCA)	
International Building Code of the International Code Council (ICC)	
International Association of Plumbing and Mechanical Officials (IAPMO)	
National Electric Code (NEC)	
National Fire Protection Association (NFPA)	
Occupational Safety and Health Administration (OSHA)	

REFERENCE STANDARDS

Title 29, Part 1926,	Construction Safety and Health Regulations, Code of Federal Regulations
Title 29, Part 1910,	Occupational Safety and Health Standards, Code of Federal Regulations
Standard Specifications for Public Works Construction (SSWPC)	

- C. References to "Building Code" or "Uniform Building Code" shall mean Uniform Building Code of the International Conference of Building Officials (ICBO). References to "Building Code" or "Standard Building Code" shall mean the Standard Building Code of the Southern Building Code Congress International. References to "Building Code" or "National Building Code" shall mean the National Building Code of Building Officials and Code Administrators International (BOCA) References to "Building Code" or International Building Code" shall mean International Building Code of the International Code Council (ICC) as amended by the local jurisdiction. Similarly, references to "Mechanical Code" or "Uniform Mechanical Code," "Plumbing Code" or "Uniform Plumbing Code," "Fire Code" or "Uniform Fire Code," shall mean Uniform Mechanical Code, Uniform Plumbing Code and Uniform Fire Code of the International Association of Plumbing and Mechanical Officials (IAPMO) as amended by the local jurisdiction. "Electric Code" or "National Electric Code (NEC)" shall mean the National Electric Code of the National Fire Protection Association (NFPA). The latest edition of the codes as approved by the Municipal Code and used by the local agency as of the date that the Work is advertised for Bids shall apply to the Work herein, including all addenda, modifications, amendments, or other lawful changes thereto.
- D. In case of conflict between codes, reference standards, drawings, and the other Contract Documents, the most stringent requirements shall govern. All conflicts shall be brought to the attention of the Engineer for clarification and direction prior to ordering or providing any materials or furnishing labor. The Contractor shall bid for the most stringent requirements.
- E. References to "OSHA Regulations for Construction" shall mean Title 29, Part 1926, Construction Safety and Health Regulations, Code of Federal Regulations (OSHA), including all changes and amendments thereto.
- F. References to "OSHA Standards" shall mean Title 29, Part 1910, Occupational Safety and Health Standards, Code of Federal Regulations (OSHA), including all changes and amendments thereto.
- G. Applicable Standard Specifications: References in the Contract Documents to "Standard Specifications" or SSPWC shall mean the Standard Specifications for Public Works Construction.

1.03 REGULATIONS RELATED TO HAZARDOUS MATERIALS

- A. The Contractor shall be responsible that all Work included in the Contract Documents, regardless if indicated or not, shall comply with all EPA, OSHA, RCRA, NFPA, and any other federal, state, and local regulations governing the storage and conveyance of hazardous materials, including petroleum products.

REFERENCE STANDARDS

- B. Where no specific regulations exist and the Owner has not waived the requirement in writing, chemical, hazardous, and petroleum product piping and storage in underground locations shall be double containment piping and tanks or be installed in separate concrete trenches and vaults with an approved lining that cannot be penetrated by the chemicals.

PART 2 -- PRODUCTS (NOT USED)

PART 3 -- EXECUTION (NOT USED)

END OF SECTION

SECTION 01 45 00– QUALITY CONTROL

PART 1 -- GENERAL

1.01 DEFINITION

- A. Specific quality control requirements for the Work are indicated throughout the Contract Documents. The requirements of this Section are primarily related to performance of the Work beyond furnishing of manufactured products. The term "Quality Control" includes inspection, sampling and testing, and associated requirements.

1.02 INSPECTION AT PLACE OF MANUFACTURE

- A. Unless otherwise indicated, all products, materials, and equipment shall be subject to inspection by the Engineer at the place of manufacture.
- B. The presence of the Engineer at the place of manufacturer, however, shall not relieve the Contractor of the responsibility for providing products, materials, and equipment which comply with all requirements of the Contract Documents. Compliance is a duty of the Contractor and said duty shall not be avoided by any act or omission on the part of the Engineer.

1.03 SAMPLING AND TESTING

- A. Unless otherwise indicated, all sampling and testing will be in accordance with the methods prescribed in the current standards of the ASTM, as applicable to the class and nature of the article or materials considered; however, the Owner reserves the right to use any generally-accepted system of sampling and testing which, in the opinion of the Engineer will assure the Owner that the quality of the workmanship is in full accord with the Contract Documents.
- B. Any waiver by the Owner of any specific testing or other quality assurance measures, whether or not such waiver is accompanied by a guarantee of substantial performance as a relief from the testing or other quality assurance requirements originally indicated, and whether or not such guarantee is accompanied by a performance bond to assure execution of any necessary corrective or remedial Work, shall not be construed as a waiver of any requirements of the Contract Documents.
- C. Notwithstanding the existence of such waiver, the Engineer reserves the right to make independent investigations and tests, and failure of any portion of the Work to meet any of the requirements of the Contract Documents, shall be reasonable cause for the Engineer to require the removal or correction and reconstruction of any such Work in accordance with the General Conditions.

1.04 INSPECTION AND TESTING SERVICE

- A. Inspection and testing laboratory service shall comply with the following:
 - 1. Unless indicated otherwise by the Technical Specifications, the Owner will appoint, employ, and pay for services of an independent firm to perform inspection and testing or will perform inspection and testing itself.

2. The Owner or independent firm will perform inspections, testings, and other services as required by the Engineer under Paragraph 1.03C above.
3. Reports of testing, regardless of whether the testing was the Owner's or the Contractor's responsibility, will be submitted to the Engineer, indicating observations and results of tests and indicating compliance or non-compliance with Contract Documents.
4. The Contractor shall cooperate with the Owner or independent firm and furnish samples of materials, design mix, equipment, tools, storage, and assistance as requested.
5. The Contractor shall notify Engineer 24 hours prior to the expected time for operations requiring inspection and laboratory testing services.
6. Retesting required because of non-conformance to requirements shall be performed by the same independent firm on instructions by the Engineer. The Contractor shall bear all costs from such retesting.
7. For samples and tests required for Contractor's use, the Contractor shall make arrangements with an independent firm for payment and scheduling of testing. The cost of sampling and testing for the Contractor's use shall be the Contractor's responsibility.

PART 2 -- PRODUCTS (NOT USED)

PART 3 -- EXECUTION

3.01 INSTALLATION

- A. Inspection: The Contractor shall inspect materials or equipment upon the arrival on the job site and immediately prior to installation and reject damaged and defective items.
- B. Measurements: The Contractor shall verify measurements and dimensions of the Work, as an integral step of starting each installation.
- C. Manufacturer's Instructions: Where installations include manufactured products, the Contractor shall comply with manufacturer's applicable instructions and recommendations for installation, to whatever extent these are more explicit or more stringent than applicable requirements indicated in Contract Documents.

END OF SECTION

SECTION 01 50 00– MOBILIZATION

PART 1 -- GENERAL

1.01 THE SUMMARY

- A. Contractor shall mobilize as required for the proper performance and completion of the Work and in accordance with the Contract Documents.
- B. Mobilization shall include at least the following items:
 - 1. Moving equipment necessary for operations to Site.
 - 2. Installing temporary construction power, wiring, and lighting facilities.
 - 3. Developing construction water supply.
 - 4. Arranging for and erection of Contractor's Work and staging area.
 - 5. Constructing and implementing security features and requirements complying with Section 01 35 53 – Site Security.
 - 6. Obtaining required permits.
 - 7. Having OSHA required notices and establishing safety programs.
 - 8. Having the Contractor's superintendent at the Site full time.
 - 9. Submitting initial submittals.

1.02 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

A. Reference Specifications

01 35 53	Site Security
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1.03 PAYMENT FOR MOBILIZATION

- A. The Contractor's attention is directed to the condition that no payment for mobilization, or any part thereof, will be recommended for payment under the Contract until mobilization items listed above have been completed.

PART 2 -- PRODUCTS (NOT USED)

PART 3 -- EXECUTION (NOT USED)

END OF SECTION

SECTION 01 50 10– PROTECTION OF EXISTING FACILITIES

PART 1 -- GENERAL

1.01 GENERAL

- A. The Contractor shall protect all existing utilities and improvements not designated for removal and shall restore damaged or temporarily relocated utilities and improvements to a condition equal to or better than prior to such damage or temporary relocation, all in accordance with the Contract Documents. Initial condition shall be based on condition shown in preconstruction photography and videos.

1.02 RIGHTS-OF-WAY

- A. The Contractor shall not do any Work that would affect any oil, gas, sewer, or water pipeline; any telephone, telegraph, or electric transmission line; any fence; or any other structure, nor shall the Contractor enter upon the rights-of-way involved until notified that the Owner has secured authority from the proper party.
- B. After authority has been obtained, the Contractor shall give said party due notice of its intention to begin work, if required by said party, and shall remove, shore, support, or otherwise protect such pipeline, transmission line, ditch, fence, or structure, or replace the same.

1.03 PROTECTION OF SURVEY AND STREET OR ROADWAY MARKERS

- A. The Contractor shall not destroy, remove, or otherwise disturb any existing survey markers or other existing street or roadway markers without proper authorization. No pavement breaking or excavation shall be started until all survey or other permanent marker points that will be disturbed by the construction operations have been properly referenced. Survey markers or points disturbed by the Contractor shall be restored after street or roadway resurfacing has been completed.

1.04 RESTORATION OF PAVEMENT

- A. General: All paved areas including asphaltic concrete berms cut or damaged during construction shall be replaced with similar materials of equal thickness to match the existing adjacent undisturbed areas, except where specific resurfacing requirements have been called for in the Contract Documents or in the requirements of the agency issuing the permit. The pavement restoration requirement to match existing sections shall apply to all components of existing sections, including sub-base, base, and pavement. Temporary and permanent pavement shall conform to the requirements of the affected pavement owner. Pavements which are subject to partial removal shall be neatly saw cut in straight lines.
- B. Temporary Resurfacing: Wherever required by the public authorities having jurisdiction, the Contractor shall place temporary surfacing promptly after backfilling and shall maintain such surfacing for the period of time fixed by said authorities before proceeding with the final restoration of improvements.

- C. Permanent Resurfacing: In order to obtain a satisfactory junction with adjacent surfaces, the Contractor shall saw cut back and trim the edge so as to provide a clean, sound, vertical joint before permanent replacement of an excavated or damaged portion of pavement. Damaged edges of pavement along excavations and elsewhere shall be trimmed back by saw cutting in straight lines. All pavement restoration and other facilities restoration shall be constructed to finish grades compatible with adjacent undisturbed pavement.
- D. Restoration of Sidewalks or Private Driveways: Wherever sidewalks or private roads have been removed for purposes of construction, the Contractor shall place suitable temporary sidewalks or roadways promptly after backfilling and shall maintain them in satisfactory condition for the period of time fixed by the authorities having jurisdiction over the affected portions. If no such period of time is so fixed, the Contractor shall maintain said temporary sidewalks or roadways until the final restoration thereof has been made.

1.05 EXISTING UTILITIES AND IMPROVEMENTS

- A. General: The Contractor shall protect underground Utilities and other improvements which may be impaired during construction operations, regardless of whether or not the Utilities are indicated on the Drawings. The Contractor shall take all possible precautions for the protection of unforeseen Utility lines to provide for uninterrupted service and to provide such special protection as may be necessary. Utilities and other improvements which are adjacent but not included within the limits of an excavation required for performance of the Work shall be protected, supported, and maintained by the Contractor at his expense.
- B. Except where the Drawings indicate Utilities have been field located during design or certain Utility locations shall be exposed as part of the Work, the Contractor shall be responsible for exploratory excavations as it deems necessary to determine the exact locations and depths of Utilities which may interfere with its work. All such exploratory excavations shall be performed as soon as practicable after Notice to Proceed and, in any event, a sufficient time in advance of construction to avoid possible delays to the Contractor's progress. When such exploratory excavations show the Utility location as shown on the Drawings to be in error, the Contractor shall so notify the Owner.
- C. The number of exploratory excavations required shall be that number which is sufficient to determine the alignment and grade of the Utility.
- D. Utilities to be Moved: In case it shall be necessary to move the property of any public utility or franchise holder, such utility company or franchise holder will, upon request of the Contractor, be notified by the Owner to move such property within 30 days. When utility lines that are to be removed are encountered within the area of operations, the Contractor shall notify the Owner 30 days in advance for the necessary measures to be taken to prevent interruption of service.

- E. Utilities to be Removed: Where the proper completion of the Work requires the temporary or permanent removal and/or relocation of an existing Utility or other improvement which is indicated, the Contractor shall remove and, without unnecessary delay, temporarily replace or relocate such Utility or improvement in a manner satisfactory to the Engineer and the Owner of the facility. In cases of temporary removal or relocation, restoration to the former location shall be accomplished by the Contractor in a manner that will restore or replace the Utility or improvement to its former locations and to as good or better condition than found prior to removal.
- F. Utilities that Do Not Require Removal or Moving:
1. Utilities which are adjacent to but not included within the limits of an excavation required for performance of the Work shall be protected, supported, and maintained by the Contractor at no additional cost to the Owner.
 2. Utilities within the limits of the Work which can be supported and maintained in service and which do not require removal and rebuilding shall be thus supported by the Contractor at his expense, including cost of repair due to damage caused by the Contractor operations.
 - a. Supports for water and gas mains, sewers, conduits, and similar utilities shall be constructed of timber or other acceptable materials; shall be supported from undisturbed foundations and shall be sufficiently substantial to ensure protection against settlement when pipe trenches or other excavations are backfilled. In all cases where permits or inspection fees are required by utilities in connection with changes to or temporary support of their conduits, the Contractor shall secure such permits and pay all permit and inspection fees.
 - b. The Contractor shall assume full responsibility for maintaining all public service utilities in operation and shall support and protect or remove and rebuild them at his own expense. Such services shall not be interrupted without permission of the owner of the public service utilities.
- G. Owner's Right of Access: The right is reserved to the Owner and to the owners of public utilities and franchises to enter at any time upon any public street, alley, right-of-way, or easement for the purpose of making changes in their property made necessary by the Work of this Contract.
- H. Underground Utilities Indicated: Existing Utility lines that are indicated or the locations of which are made known to the Contractor prior to excavation and that are to be retained, and all Utility lines that are constructed during excavation operations shall be protected from damage during excavation and backfilling and, if damaged, shall be immediately repaired or replaced by the Contractor, unless otherwise repaired by the owner of the damaged Utility. If the owner of the damaged facility performs its own repairs, the Contractor shall reimburse said owner for the costs of repair.

- I. **Underground Utilities Not Indicated:** In the event that the Contractor damages existing Utility lines that are not indicated or the locations of which are not made known to the Contractor prior to excavation, a verbal report of such damage shall be made within 24 hours to the Owner and a written report thereof shall be made promptly thereafter. If the Owner is not immediately available, the Contractor shall notify the Utility owner of the damage. If directed by the Owner, repairs shall be made by the Contractor under the provisions for changes and extra Work contained in the General Conditions.
- J. **Costs of locating and repairing damage and removing or relocating such Utility facilities** not indicated in the Contract Documents, and for equipment on the project which was actually working on that portion of the Work which was interrupted or idled by removal or relocation of such Utility facilities, and which was necessarily idled during such work will be paid for as extra work in accordance with the provisions of the General Conditions.
- K. **Approval of Repairs:** All repairs to a damaged Utility or improvement are subject to inspection and approval by an authorized representative of the Utility or improvement owner before being concealed by backfill or other work.
- L. **Maintaining in Service:** Unless indicated otherwise, oil and gasoline pipelines, power, and telephone or the communication cable ducts, gas and water mains, irrigation lines, sewer lines, storm drain lines, poles, and overhead power and communication wires and cables encountered along the line of the Work shall remain continuously in service during all the operations under the Contract, unless other arrangements satisfactory to the Owner are made with the owner of said pipelines, duct, main, irrigation line, sewer, storm drain, pole, or wire or cable. The Contractor shall be responsible for and shall repair all damage due to its operations, and the provisions of this Section shall not be abated even in the event such damage occurs after backfilling or is not discovered until after completion of the backfilling.

1.06 TREES OR SHRUBS WITHIN STREET RIGHTS-OF-WAY AND PROJECT LIMITS

- A. **General:** Except where trees or shrubs are indicated to be removed, the Contractor shall exercise all necessary precautions so as not to damage or destroy any trees or shrubs, including those lying within street rights-of-way and project limits, and shall not trim or remove any trees unless such trees have been approved for trimming or removal by the jurisdictional agency or owner. Existing trees and shrubs which are damaged during construction shall be trimmed or replaced by a certified tree specialist under permit from the jurisdictional agency and/or the Owner and paid for by the Contractor. Tree trimming and replacement shall be accomplished in accordance with the following paragraphs.
- B. **Trimming:** Symmetry of the tree shall be preserved; no stubs or splits or torn branches left; clean cuts shall be made close to the trunk or large branch. Spikes shall not be used for climbing live trees. Cuts over 1 1/2 inches in diameter shall be coated with a tree paint product that is waterproof, adhesive, and elastic, and free from kerosenes, coal tar, creosote, or other material injurious to the life of the tree.

- C. Replacement: The Contractor shall immediately notify the jurisdictional agency and the Owner if any tree or shrub is damaged by the Contractor's operations. If, the jurisdictional agency or the Owner's licensed arborist, determines that the damage is such that replacement is necessary, the Contractor shall replace the tree or shrub at its own expense. The tree or shrub shall be of a like size and variety as the one damaged, or, if of a smaller size, the Contractor shall pay to the owner of said tree a compensatory payment acceptable to the tree or shrub owner, subject to the approval of the jurisdictional agency or owner. The size of the tree or shrub shall be not less than 1 inch diameter nor less than 6 feet in height. Planting of replacement trees and shrubs shall be in accordance with the recommendations of the nursery furnishing the plants. Unless otherwise indicated, the Contractor shall water and maintain the replacement trees and shrubs for 6 months after planting.

1.07 LAWN AREAS

- A. Lawn or landscaped areas damaged during construction shall be repaired to match the pre-construction condition as indicated by the preconstruction photographs and videos.

1.08 PROTECTION OF STREAMS AND WATERWAYS

- A. Stream or waterway bank trees, shrubs, and other vegetation should be left in place to help control erosion; where equipment operation requires tree removal, stumps and roots are to remain in place to help anchor the stream bank. Clearing of the stream or waterway banks should be avoided until immediately proceeding construction.
- B. Prior to the onset of any stream or waterway crossing, silt barriers shall be placed along the banks where vegetation removal has occurred or is anticipated, exposed soil exists, and/or spoils or other fill materials are to be stockpiled within 50 feet of the stream or waterway.
- C. Construction within a stream or waterway will be continued until completed. A stream or waterway crossing shall not be initiated unless the Contractor is prepared to finish the work immediately. Also, work must not be initiated unless time and weather constraints have been provided for. Stream or waterway crossing work shall be restricted to periods of dry weather and low-flow conditions.
- D. Backfill should be placed to extend the full width of the trench and the full length of the stream or waterway crossing as called for on the drawings. The balance of the trench should be filled so as to conform to the existing stream or waterway bed and banks.
- E. Restoration should include the re-establishment of channel contours and bank stabilization and should be initiated immediately after the crossing is completed. Limit the use of rip-rap or similar stabilization techniques to areas where stream or waterway flow conditions prevent vegetative stabilization.
- F. The width of the easement for the stream or waterway crossing should be restricted to only that necessary to perform the work.
- G. Construction materials, supplies, equipment, excavated materials, construction debris, and any other work-related items should be stored, placed and/or operated so as to minimize interference with normal stream or waterway flow and shall be kept out of the stream or waterway channel except during actual pipe installation.

PROTECTION OF EXISTING FACILITIES

1.09 PROTECTION OF ARCHAEOLOGICAL/HISTORICAL RESOURCES

- A. If, during the course of construction, evidence of deposits of historical and/or archaeological interest is found, the Contractor and subcontractors are required under Ohio Revised Code Section 149.53 to notify the Ohio Historic Preservation Office (OHPO). Upon discovery, the Contractor will cease operations and no further disturbance of the area will occur until an official from regulating agency has surveyed the find, made a determination of the value of the find and effect of continued construction disturbances, and submitted the results of the determination to the Owner.

1.10 NOTIFICATION BY THE CONTRACTOR

- A. Prior to any excavation in the vicinity of any existing underground facilities, including all water, sewer, storm drain, gas, petroleum products, or other pipelines; all buried electric power, communications, or television cables; all traffic signal and street lighting facilities; and all roadway and state highway rights-of-way, the Contractor shall notify the respective authorities representing the owners or agencies responsible for such facilities not less than 3 business days nor more than 7 business days prior to excavation so that a representative of said owners or agencies can be present during such work if they so desire. The Contractor shall also notify Ohio Utilities Protection Service (OUPS).

PART 2 -- PRODUCTS (NOT USED)

PART 3 -- EXECUTION (NOT USED)

END OF SECTION

SECTION 01 51 00– TEMPORARY UTILITIES

PART 1 -- GENERAL

1.01 SUMMARY

- A. The types of utility services required for general temporary use at the Site include but are not limited to the following:
 - 1. Water service (potable for certain uses)
 - 2. Storm sewer
 - 3. Sanitary sewer
 - 4. Electric power service
 - 5. Telephone service
 - 6. Gas service
 - 7. Heating and cooling
- B. The Contractor shall provide the specified temporary utilities required in order to execute the Work expeditiously. Remove the temporary utilities from the Site upon completion of the Work unless specified otherwise.

1.02 JOB CONDITIONS

- A. Scheduled Uses: The Contractor, in conjunction with establishing the progress schedule, shall establish a schedule for implementation and termination of service for each temporary utility at the earliest feasible time, and when approved by the Owner, change over from temporary utility service to permanent service.

1.03 PERMITTING

- A. The Contractor shall make necessary applications to authorities having jurisdiction, obtain required permits, and pay all fees and related charges.

1.04 TEMPORARY USE OF OWNER'S FACILITIES

- A. Permanent systems shall not be used without the written permission of the Owner.
- B. If written permission is obtained to use existing heating systems or other systems temporarily before completion, entirely change lubricants, filters and other accessory items upon completion of the Work. Extend warranties to ensure that The Owner receives coverage for the full warranty period, as specified.
- C. Temporary or trial usage of any mechanical machinery, apparatus, equipment or any other work or materials by The Owner supplied under the Work before final acceptance by the Owner is not to be construed as evidence of acceptance. The Owner shall have the privilege of such temporary and trial usage as soon as the Contractor claims that the Work is complete.

PART 2 -- PRODUCTS

2.01 MATERIALS

- A. The Contractor shall provide either new or used materials and equipment, that are in substantially undamaged condition and without significant deterioration and which are recognized in the construction industry by compliance with appropriate standards, as being suitable for intended use in each case. Where a portion of temporary utility is provided by utility company, the Contractor shall provide the remaining portion with matching and compatible materials and equipment and shall comply with recommendations of the utility company.

PART 3 -- EXECUTION

3.01 INSTALLATION OF TEMPORARY UTILITY SERVICES

- A. General: Wherever feasible, the Contractor shall engage the utility company to install temporary service to the Site, or as a minimum, to make connection to existing utility service; locate services where they will not interfere with Work, including installation of permanent utility services; and maintain temporary services as installed for required period of use; and relocate, modify or extend as necessary from time to time during that period as required to accommodate the Work.
- B. The Contractor shall pay all costs for installation, maintenance, consumption, and removal of temporary utilities.
- C. Approval of Electrical Connections: Temporary connections for electricity shall be subject to approval of the power company representative and shall be removed in like manner at the Contractor's expense prior to final acceptance of the Work.
- D. Separation of Circuits: Circuits used for power purposes shall be separate from lighting circuits.
- E. Construction Wiring: Wiring for temporary electric light and power shall be properly installed and maintained and shall be securely fastened in place. Electrical facilities shall conform to the requirements of Subpart K of the OSHA Safety and Health Standards for Construction.

3.02 INSTALLATION OF POWER DISTRIBUTION SYSTEM

- A. Power: The Contractor shall provide power required for its operations under the Contract and shall provide and maintain temporary power lines required to perform the Work in a safe and satisfactory manner. The Contractor shall arrange with the utility company to extend electric service to the Project Work Site, connect temporary service in a manner directed by the utility company officials, and provide separate meter for metering of power used by all entities authorized to be at or perform Work at the Project Work Site.

- B. Temporary Power Distribution: The Contractor shall provide a weatherproof, grounded, temporary power distribution system sufficient for performance of the entire Work, including temporary electrical heating where indicated, operation of test equipment and test operation of building equipment and systems which cannot be delayed until permanent power connections are operable, temporary operation of other temporary facilities, including permanent equipment and systems which must be placed in operation prior to use of permanent power connections (pumps, HVAC equipment, elevators, and similar equipment), and power for temporary operation of existing facilities (if any) at the Site during change-over to new permanent power system. Provide circuits of adequate size and proper power characteristics for each use; run circuit wiring generally overhead, and rise vertically in locations where it will be least exposed to possible damage from construction operations and will result in minimal interference with performance of the Work; provide rigid steel conduit or equivalent raceways for wiring which must be exposed on grade, floors, decks, or other exposures to damage or abuse.

3.03 INSTALLATION OF LIGHTING

- A. Construction Lighting: Work conducted at night or under conditions of deficient daylight shall be suitably lighted in accordance with local lighting ordinances (specific lumens for a distance or radius) and to afford adequate facilities for inspection and safe working conditions. Lighting shall be provided and maintained adequately to safely perform the Work. Contractor shall provide a general, weatherproof, grounded temporary lighting system in every area of construction as soon as overhead floor/roof deck structure has been installed to provide sufficient illumination for safe working and traffic conditions. Run circuit wiring generally overhead and rise vertically in locations where it will be least exposed to possible damage from construction operations on grade, floors, decks, or other areas of possible damage or abuse.
- B. Light pollution off the Site shall be avoided and the construction lighting impact off the Site shall be addressed in the Construction Management plan in accordance with the local lighting ordinance.

3.04 WATER SUPPLY

- A. General: The Contractor shall coordinate with the Water Utilities Department for obtaining water service connection and shall allow a 2 week notice to the Water Utilities Department. The Contractor shall provide facilities necessary to convey the water from the source to the points of use such as reduced pressure backflow preventers, hydrant meters, and NSF 61 piping in accordance with the requirements of the Contract Documents. Water capacity charges and the wet tap fees will be paid by the Owner. The Contractor shall pay the fee for water meter and other charges for water use.
- B. Water Connections: The Contractor shall not make connection to or draw water from any fire hydrant or pipeline without first obtaining permission of the authority having jurisdiction over the use of said fire hydrant or pipeline and from the agency owning the affected water system. For each such connection made, the Contractor shall first attach to the fire hydrant or pipeline a reduced pressure backflow preventer, valve and meter, of a size and type acceptable to said authority and agency. The Contractor shall pay permit and water charges.

- C. The Contractor shall comply with disinfection and testing requirements as if the temporary water supply system was a permanent system.

3.05 INSTALLATION OF SANITARY FACILITIES

- A. Toilet Facilities: Fixed or portable chemical toilets shall be provided wherever needed for the use of Contractor's employees and visitors. Toilets at construction sites shall conform to the requirements of Subpart D, Section 1926.51 of the OSHA Standards for Construction.
- B. Sanitary and Other Organic Wastes: The Contractor shall establish a regular daily collection of sanitary and organic wastes. Wastes and refuse from sanitary facilities provided by the Contractor or organic material wastes from any other source related to the Contractor's operations shall be disposed of away from the Site in accordance with laws and regulations pertaining thereto.
- C. Contractor shall provide toileting consumables and maintain sanitation facilities in a clean condition for the duration of the Work.
- D. Sewer Connection: The Contractor shall coordinate with the Utilities Department for obtaining sewer connection and shall pay permit and sewer usage charges. The sewer capacity charges will be paid by the Owner.

3.06 INSTALLATION OF FIRE PROTECTION

- A. Fire Protection: The construction plant and the Work shall be connected with the Contractor's temporary water supply system and shall be adequately protected against damage by fire. Hose connections and hose, water casks, chemical equipment, or other sufficient means shall be provided for fighting fires in the temporary structures and other portions of the Work, and responsible persons shall be designated and instructed in the operation of such fire apparatus so as to prevent or minimize the hazard of fire. The Contractor's fire protection program shall conform to the requirements of Subpart F of the OSHA Standards for Construction.

3.07 INSTALLATION OF GAS SERVICE

- A. Gas Service: The Contractor shall install gas service and distribution piping of size adequate for temporary heating of enclosed construction Work, construction offices, toilets, fabrication shops and similar temporary facilities requiring heat.

3.08 INSTALLATION OF COMMUNICATIONS

- A. Telephone Services: The Contractor shall provide and maintain during the progress of the Work not less than one telephone in good working order at its own field construction office at or near the Site. Each such telephone shall be connected to an established exchange for toll service and with other telephones utilized by Contractor.
- B. Telephone Use: The Contractor shall permit the Owner or Owner's representatives free and unlimited use of said telephone facilities for calls that do not involve published toll charges. Calls originated by the Owner or Owner's representatives which involve toll or message unit charges shall be billed to the Owner by the Contractor at the rates charged by the telephone company.

TEMPORARY UTILITIES

- C. Mobile Telephone Service: The Contractor shall arrange with the local cellular/mobile telephone service company to provide mobile telephone service for the use by Contractor and so Contractor can be reached throughout the entire Project area during working hours. This may require the use of mobile “hotspots”.

3.09 INSTALLATION OF HEATING AND COOLING

- A. Temporary Heating and Cooling: Provide temporary heating and cooling system required by construction activities for curing or drying of completed installations or for protecting installed construction from adverse effects of low temperatures or high humidity. Select equipment that will not have a harmful effect on completed installations or elements being installed.
- B. Provide temporary dehumidification systems when required to reduce ambient and substrate moisture levels to level required to allow installation or application of finishes and their proper curing or drying.
- C. Temporary heating and cooling systems shall be paid for by the Contractor.

3.10 OPERATIONS AND TERMINATIONS

- A. Inspections: Prior to placing temporary utility services into use, the Contractor shall inspect and test each service and arrange for governing authorities' required inspection and tests and obtain required certifications and permits for use thereof.
- B. Protection: The Contractor shall maintain distinct markers for underground lines and protect from damage during excavating operations.
- C. Termination and Removal: When need for a temporary utility service or a substantial portion thereof has ended, or when its service has been replaced by use of permanent services, or not later than time of substantial completion, the Contractor shall promptly remove installation unless requested by the Owner to retain it for a longer period. The Contractor shall complete and restore Work which may have been delayed or affected by installation and use of temporary utility, including repairs to construction and grades and restoration and cleaning of exposed surfaces.
- D. Removal of Water Connections: Before final acceptance of the Work on the project, temporary connections and piping installed by the Contractor shall be entirely removed and affected improvements shall be restored to original condition in accordance with the preconstruction video and photographs, to the satisfaction of the Owner and to the agency owning the affected utility.

END OF SECTION

SECTION 01 55 00– SITE ACCESS AND STORAGE

PART 1 -- GENERAL

1.01 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

A. Reference Standards

American National Standards Institute (ANSI)	
ANSI D6.1	Manual on Uniform Traffic Control Devices for Streets and Highways

1.02 HIGHWAY LIMITATIONS

- A. The Contractor shall make its own investigation of the condition of available public and private roads and of clearances, restrictions, bridge load limits, and other limitations affecting transportation and ingress and egress to the site of the Work. It shall be the Contractor's responsibility to construct and maintain any haul roads required for its construction operations.

1.03 TEMPORARY CROSSINGS

- A. General: Continuous, unobstructed, safe, and adequate pedestrian and vehicular access shall be provided to fire hydrants, commercial and industrial establishments, churches, schools, parking lots, service stations, motels, fire and police stations, and hospitals. Safe and adequate public transportation stops and pedestrian crossings at intervals not exceeding 300-feet shall be provided. The Contractor shall cooperate with parties involved in the delivery of mail and removal of trash and garbage so as to maintain existing schedules for such services. Vehicular access to residential driveways shall be maintained to the property line except when necessary, construction precludes such access for reasonable periods of time.
- B. Temporary Bridges: Wherever necessary, to maintain vehicular crossings, the Contractor shall provide suitable temporary bridges or steel plates over unfilled excavations, except in such cases as the Contractor shall secure the written consent of the responsible individuals or authorities to omit such temporary bridges or steel plates, which written consent shall be delivered to the Engineer prior to excavation. Such bridges or steel plates shall be maintained in service until access is provided across the backfilled excavation. Temporary bridges or steel plates for street and highway crossing shall conform to the requirements of the authority having jurisdiction in each case, and the Contractor shall adopt designs furnished by said authority for such bridges or steel plates, or shall submit designs to said authority for approval, as may be required.

- C. **Street Use:** Nothing herein shall be construed to entitle the Contractor to the exclusive use of any public street, alleyway, or parking area during the performance of the Work hereunder, and it shall conduct its operations to not interfere unnecessarily with the authorized work of utility companies or other agencies in such streets, alleyways, or parking areas. No street shall be closed to the public without first obtaining permission of the Engineer and proper governmental authority. Where excavation is being performed in primary streets or highways, one lane in each direction shall be kept open to traffic at all times unless otherwise indicated. Toe boards shall be provided to retain excavated material if required by the Engineer or the agency having jurisdiction over the street or highway. Fire hydrants on or adjacent to the Work shall be kept accessible to fire-fighting equipment. Temporary provisions shall be made by the Contractor to assure the use of sidewalks and the proper functioning of gutters, storm drain inlets, and other drainage facilities.
- D. **Traffic Control:** For the protection of traffic in public or private streets and ways, the Contractor shall provide, place, and maintain necessary barricades, traffic cones, warning signs, lights, and other safety devices in accordance with the requirements of the current Ohio Manual of Uniform Traffic Control Devices.
1. The Contractor shall take necessary precautions for the protection of the Work and the safety of the public. Barricades and obstructions shall be illuminated at night, and lights shall be kept burning from sunset until sunrise. The Contractor shall station such guards or flaggers and shall conform to such special safety regulations relating to traffic control as may be required by the public authorities within their respective jurisdictions. Signs, signals, and barricades shall conform to the requirements of Subpart G, Part 1926, of the OSHA Safety and Health Standards for Construction.
 2. The Contractor shall submit 1 electronic copy of a traffic control plan to the City Engineer for approval a minimum of 2 weeks prior to construction. The City Engineer shall be allowed access to observe these traffic control plans in use and to make any changes as field conditions warrant. Any changes required by the City Engineer shall supersede these plans and be done solely at the Contractor's expense.
 3. The Contractor shall remove traffic control devices when no longer needed, repair damage caused by installation of the devices, and shall remove post settings and backfill the resulting holes to match grade.
- E. **Temporary Street Closure:** If closure of any street is required during construction, the Contractor shall apply in writing to the City Engineer and any other jurisdictional agency at least 30 Days in advance of the required closure. A Detour and Traffic Control Plan shall accompany the application.
- F. **Temporary Driveway Closure:** The Contractor shall notify the owner or occupant (if not owner-occupied) of the closure of the driveways to be closed more than one 8 hour work day at least 3 working days prior to the closure. The Contractor shall minimize the inconvenience and minimize the time period that the driveways will be closed. The Contractor shall fully explain to the owner/occupant how long the closure will take and when closure will start.

1.04 CONTRACTOR'S WORK AND STORAGE AREA

- A. The Owner will designate and arrange for the Contractor's use, a portion of the property adjacent to the Work for its exclusive use during the term of the Contract as a storage and shop area for its construction operations on the Work. At completion of Work, the Contractor shall return this area to its original condition, including grading and landscaping.
- B. The Contractor shall make its own arrangements for any necessary off-Site storage or shop areas necessary for the proper execution of the Work.
- C. Lands to be furnished by the Owner for WORK sites, construction operations, concrete aggregate pits, roads, and other purposes are indicated. Should the Contractor find it necessary to use any additional land for its WORK or for other purposes during the construction of the Work, they shall arrange for the use of such lands at their own expense.
- D. The Contractor shall construct and use a separate storage area for hazardous materials used in constructing the Work.
 - 1. For the purpose of this paragraph, hazardous materials to be stored in the separate area are products labeled with any of the following terms: Warning, Caution, Poisonous, Toxic, Flammable, Corrosive, Reactive, or Explosive. In addition, whether or not so labeled, the following materials shall be stored in the separate area: diesel fuel, gasoline, new and used motor oil, hydraulic fluid, cement, paints and paint thinners, 2 part epoxy coatings, sealants, asphaltic products, glues, solvents, wood preservatives, sand blast materials, and spill absorbent.
 - 2. Hazardous materials shall be stored in groupings according to the Material Safety Data Sheets.
 - 3. The Contractor shall develop and submit to the Engineer a plan for storing and disposing of the materials above.
 - 4. The Contractor shall obtain and submit to the Engineer a single EPA number for wastes generated at the Site.
 - 5. The separate storage area shall meet the requirements of authorities having jurisdiction over the storage of hazardous materials.
 - 6. The separate storage area shall be inspected by the City of Warren prior to construction of the area, upon completion of construction of the area, and upon cleanup and removal of the area.
 - 7. Hazardous materials that are delivered in containers shall be stored in the original containers until use. Hazardous materials delivered in bulk shall be stored in containers which meet the requirements of authorities having jurisdiction.

1.05 PARKING

- A. The Contractor shall:

1. Provide temporary parking areas. The number of spaces shall be sufficient to hold the automobiles of the construction personnel, the ENGINEER, and the OWNER simultaneously.
2. When space on the Site is not available, the Contractor shall make 2 additional spaces available for the OWNER's use.
3. The Contractor shall direct its employees to park in areas indicated.
4. Traffic and parking areas shall be maintained in a sound condition, free of excavated material, construction equipment, mud, and construction materials. The Contractor shall repair breaks, potholes, low areas which collect standing water, and other deficiencies.

PART 2 -- PRODUCTS (NOT USED)

PART 3 -- EXECUTION (NOT USED)

END OF SECTION

SECTION 01 57 19– TEMPORARY ENVIRONMENTAL CONTROLS

PART 1 -- GENERAL

1.01 DUST ABATEMENT

- A. The Contractor shall prevent its operation from producing dust in amounts damaging to property, cultivated vegetation, or domestic animals, or causing a nuisance to persons living in or occupying buildings in the vicinity of the Site. The Contractor shall be responsible for any damage resulting from dust originating from its operations. Dust abatement measures shall be continued until the Contractor is relieved of further responsibility by the Engineer.
- B. Storage Piles: Enclose, cover, water (as needed), or apply non-toxic soil binders according to manufacturer's specifications on material piles (i.e. gravel, sand, dirt) with a silt content of 5 percent or greater.
- C. Active Areas of Site: Water active construction areas and unpaved roads as needed and as requested by Engineer.
- D. Inactive Areas of Site: Apply non-toxic soil stabilizers according to manufacturer's specifications to inactive construction areas, or water as needed to maintain adequate dust control.
- E. Vehicle Loads: Cover or maintain at least 2-feet of freeboard vertical distance between the top of the load and the top of the trailer sides on trucks hauling dirt, sand, soil, or other loose materials off of the Site.
- F. Roads: When there is visible track-out onto a paved public road, install wheel washers where the vehicles exit and enter onto the paved roads and wash the undercarriage of trucks and any equipment leaving the Site on each trip. Sweep the paved street at the end of each shift with mobile water spray pick-up broom-type street sweeper as necessary or as directed.
- G. Vehicle Speeds: If watering of unpaved roads is not sufficient to control dust, reduce vehicle speeds to 15 mph or less on such roads.

1.02 SEDIMENTATION ABATEMENT

- A. The Contractor shall be responsible for collecting, storing, hauling, and disposing of spoil, silt, and waste materials in compliance with applicable federal, state, and local rules and regulations and the Contract Documents.
- B. Install and maintain erosion and sediment control measures, such as swales, grade stabilization structures, berms, dikes, waterways, filter fabric fences, and sediment basins.
- C. Filter fabric barrier systems, if used, shall be installed in such a manner that surface runoff will percolate through the system in sheet flow fashion and allow sediment to be retained and accumulated.

- D. Remove and dispose of sediment deposits at the designated spoil area. If a spoil area is not indicated, dispose of sediment off-Site at a location not in or adjacent to a stream or floodplain. Sediment to be placed at the spoil area should be spread evenly, compacted, and stabilized. Sediment shall not be allowed to flush into a stream or drainage way.
- E. Maintain erosion and sediment control measures until final acceptance or until requested by the Engineer to remove it.

1.03 STORMWATER POLLUTION PREVENTION

- A. Contractor shall minimize stormwater pollution from the Site in accordance with Storm Water Pollution Prevention Plan.

1.04 RUBBISH CONTROL

- A. During the progress of the Work, the Contractor shall keep the Site and other areas for which it is responsible in a neat and clean condition and free from any accumulation of rubbish. The Contractor shall dispose of rubbish and waste materials of any nature and shall establish regular intervals of collection and disposal of such materials and waste. The Contractor shall also keep its haul roads free from dirt, rubbish, and unnecessary obstructions resulting from its operations. Disposal of rubbish and surplus materials shall be off the Site in accordance with local codes and ordinances governing locations and methods of disposal and in conformance with applicable safety laws and the particular requirements of Part 1926 of the OSHA Safety and Health Standards for Construction.

1.05 SANITATION

- A. Toilet Facilities: Fixed or portable chemical toilets shall be provided wherever needed for the use of employees. Toilets shall conform to the requirements of Part 1926 of the OSHA Standards for Construction.
- B. Sanitary and Other Organic Wastes: The Contractor shall establish a regular daily collection of sanitary and organic wastes. Wastes and refuse from sanitary facilities provided by the Contractor or organic material wastes from any other source related to the Contractor's operations shall be disposed of away from the Site in a manner satisfactory to the Engineer and in accordance with Laws and Regulations pertaining thereto.

1.06 CHEMICALS

- A. Chemicals used on the Work or furnished for facility operation, whether defoliant, soil sterilant, herbicide, pesticide, disinfectant, polymer, reactant, or of other classification, shall show approval of either the U.S. Environmental Protection Agency or the U.S. Department of Agriculture. Use of such chemicals and disposal of residues shall be in strict accordance with the printed instructions of the manufacturer.

1.07 CULTURAL RESOURCES

- A. The Contractor's attention is directed to the National Historic Preservation Act of 1966 (16 U.S.C. 470) and 36 CFR 800 which provides for the preservation of potential historical architectural, archaeological, or cultural resources (hereinafter called "cultural resources").
- B. In the event potential cultural resources are discovered during subsurface excavations at the Site, the following procedures shall be instituted:
 - 1. The Owner will issue a temporary Notice to Suspend Work directing the Contractor to cease construction operations at the location of such potential cultural resources find.
 - 2. The suspension Notice will contain the following:
 - a. A clear description of the Work to be suspended
 - b. Instructions regarding issuance of further orders by the Contractor for material services
 - c. Guidance as to the action to be taken on subcontracts
 - d. Suggestions to the Contractor to minimize incurred costs
 - e. Estimated duration of the temporary suspension.
 - 3. Such suspension shall be effective until such time as a qualified archeologist can assess the value of the potential cultural resources and make recommendations to the State Water Resources Control Board Cultural Resources Officer.
 - 4. The Owner will implement appropriate actions as directed by the State Board Cultural Resources Officer or Project Manager. The Contractor shall cease Work in the area of a discovery until appropriate actions have been determined in accordance with this paragraph.
 - 5. If human remains are discovered, Work in the immediate vicinity of the find shall stop. The County Coroner shall be notified.
- C. If the archeologist determines that the potential find is a bonafide cultural resource, at the direction of the State Water Resources Control Board Cultural Resources Officer, the Owner will extend the duration of the suspension.
- D. Changes to the Contract Price and Contract Times for suspension due to discovery of a potential cultural resource will be made in the following manner:
 - 1. Contract Times
 - a. If the Work temporarily suspended is on the "critical path", the total number of Days for which the suspension is in effect will be added to the Contract Times.

- b. If a portion of Work at the time of such suspension is not on the “critical path”, but subsequently becomes Work on the critical path, the Contract Times will be computed from the date such Work is classified as on the critical path.

2. Contract Price

- a. If, as a result of a cultural resources suspension, the Contractor sustains a loss that could not have been avoided by judicious handling of forces and equipment or redirection of forces or equipment to perform other Work on the contract, there will be paid an amount based on time and materials for the loss in accordance with the following:
 - 1) Idle Time of Equipment: Compensation for equipment idle time will be determined in accordance with the General Conditions for equipment time and equipment rental time.
 - 2) Idle Time of Labor: Compensation for idle time of workers will be determined in accordance with the General Conditions for labor.
- b. Costs of labor will be compensated only to the extent such cost was in fact caused by the suspension.
- c. Compensation for loss due to idle time of either equipment or labor will not include markup for profit.
- d. The hours for which compensation will be paid will be the actual normal working time during which such suspension lasts but will in no case exceed eight hours in any single Day.
- e. The days for which compensation will be paid exclude Saturdays, Sundays, and legal holidays during the suspension.

PART 2 -- PRODUCTS (NOT USED)

PART 3 -- EXECUTION (NOT USED)

END OF SECTION

SECTION 01 60 00– PRODUCTS, MATERIALS, EQUIPMENT, AND SUSTITUTIONS

PART 1 -- GENERAL

1.01 DEFINITIONS

- A. The word "Products," as used in the Contract Documents, is defined to include purchased items for incorporation into the Work, regardless of whether specifically purchased for the project or taken from Contractor's stock of previously purchased products. The word "Materials," is defined as products which must be substantially cut, shaped, worked, mixed, finished, refined, or otherwise fabricated, processed, installed, or applied to form Work. The word "Equipment" is defined as products with operational parts, regardless of whether motorized or manually operated, and particularly including products with service connections (wiring, piping, and other like items). Definitions in this paragraph are not intended to negate the meaning of other terms used in the Contract Documents, including "specialties," "systems," "structure," "finishes," "accessories," "furnishings," special construction," and similar terms, which are self-explanatory and have recognized meanings in the construction industry.
- B. Neither "Products" nor "Materials" nor "Equipment" includes machinery and equipment used for preparation, fabrication, conveying, and erection of the Work.

1.02 QUALITY ASSURANCE

- A. Source Limitations: To the greatest extent possible for each unit of Work, the Contractor shall provide products, materials, and equipment of a singular generic kind from a single source.
- B. Compatibility of Options: Where more than one choice is available as options for Contractor's selection of a product, material, or equipment, the Contractor shall select an option which is compatible with other products, materials, or equipment. Compatibility is a basic general requirement of product, material and equipment selections.

1.03 PRODUCT DELIVERY AND STORAGE

- A. The Contractor shall deliver and store the Work in accordance with manufacturer's written recommendations and by methods and means which will prevent damage, deterioration, and loss including theft. Delivery schedules shall be controlled to minimize long-term storage of products at the Site and overcrowding of construction spaces. In particular, the Contractor shall ensure coordination to ensure minimum holding or storage times for flammable, hazardous, easily damaged, or sensitive materials to deterioration, theft, and other sources of loss.

1.04 TRANSPORTATION AND HANDLING

- A. Products shall be transported by methods to avoid damage and shall be delivered in undamaged condition in manufacturer's unopened containers and packaging.
- B. The Contractor shall provide equipment and personnel to handle products, materials, and equipment [including those furnished by Owner,] by methods to prevent soiling and damage.

- C. The Contractor shall provide additional protection during handling to prevent marring and otherwise damaging products, packaging, and surrounding surfaces.

1.05 STORAGE AND PROTECTION

- A. Products shall be stored in accordance with manufacturer's written instructions and with seals and labels intact and legible. Sensitive products shall be stored in weather-tight climate controlled enclosures and temperature and humidity ranges shall be maintained within tolerances required by manufacturer's recommendations.
- B. For exterior storage of fabricated products, products shall be placed on sloped supports above ground. Products subject to deterioration shall be covered with impervious sheet covering and ventilation shall be provided to avoid condensation.
- C. Loose granular materials shall be stored on solid flat surfaces in a well-drained area and shall be prevented from mixing with foreign matter.
- D. Storage shall be arranged to provide access for inspection. The Contractor shall periodically inspect to assure products are undamaged and are maintained under required conditions.
- E. Storage shall be arranged in a manner to provide access for maintenance of stored items and for inspection.

1.06 MAINTENANCE OF PRODUCTS IN STORAGE

- A. Stored products shall be periodically inspected on a scheduled basis. The Contractor shall maintain a log of inspections and shall make the log available on request.
- B. The Contractor shall comply with manufacturer's product storage requirements and recommendations.
- C. The Contractor shall maintain manufacturer-required environmental conditions continuously.
- D. The Contractor shall ensure that surfaces of products exposed to the elements are not adversely affected and that weathering of finishes does not occur.
- E. For mechanical and electrical equipment, the Contractor shall provide a copy of the manufacturer's service instructions with each item and the exterior of the package shall contain notice that instructions are included.
- F. Products shall be serviced on a regularly scheduled basis, and a log of services shall be maintained and submitted as a record document prior to final acceptance by the Owner in accordance with the Contract Documents.

1.07 PROPOSED SUBSTITUTIONS OR "OR-EQUAL" ITEM

- A. Whenever materials or equipment are indicated in the Contract Documents by using the name of a proprietary item or the name of a particular manufacturer, the naming of the item is intended to establish the type, function, and quality required. If the name is followed by the words "or equal" indicating that a substitution is permitted, materials or equipment of other manufacturers may be accepted if sufficient information is submitted by the Contractor to allow the Engineer to determine that the material or equipment proposed is equivalent or equal to that named, subject to the following requirements:
1. The burden of proof as to the type, function, and quality of any such substitution product, material or equipment shall be upon the Contractor.
 2. The Engineer will be the sole judge as to the type, function, and quality of any such substitution and the Engineer's decision shall be final.
 3. The Engineer may require the Contractor to furnish additional data about the proposed substitution.
 4. The Owner may require the Contractor to furnish a special performance guarantee or other surety with respect to any substitution.
 5. Acceptance by the Engineer of a substitution item proposed by the Contractor shall not relieve the Contractor of the responsibility for full compliance with the Contract Documents and for adequacy of the substitution.
 6. The Contractor shall pay all costs of implementing accepted substitutions, including redesign and changes to Work necessary to accommodate the substitution.
- B. The procedure for review by the Engineer will include the following:
1. If the Contractor wishes to provide a substitution item, the Contractor shall make written application to the Engineer on the "Substitution Request Form."
 2. Unless otherwise provided by law or authorized in writing by the Engineer, the "Substitution Request Form(s)" shall be submitted within the 35-day period after award of the Contract.
 3. Wherever a proposed substitution item has not been submitted within said 35-day period, or wherever the submission of a proposed substitution material or equipment has been judged to be unacceptable by the Engineer, the Contractor shall provide the material or equipment indicated in the Contract Documents.
 4. The Contractor shall certify by signing the form that the list of paragraphs on the form are correct for the proposed substitution.
 5. The Engineer will evaluate each proposed substitution within a reasonable period of time.

6. As applicable, no shop drawing submittals shall be made for a substitution item nor shall any substitution item be ordered, installed, or utilized without the Engineer's prior written acceptance of the Contractor's "Substitution Request Form."
 7. The Engineer will record the time required by the Engineer in evaluating substitutions proposed by the Contractor and in making changes by the Contractor in the Contract Documents occasioned thereby.
- C. The Contractor's application shall address the following factors which will be considered by the Engineer in evaluating the proposed substitution:
1. Whether the evaluation and acceptance of the proposed substitution will prejudice the Contractor's achievement of Substantial Completion on time.
 2. Whether acceptance of the substitution for use in the Work will require a change in any of the Contract Documents to adapt the design to the proposed substitution.
 3. Whether incorporation or use of the substitution in connection with the Work is subject to payment of any license fee or royalty.
 4. Whether all variations of the proposed substitution from the items originally specified are identified.
 5. Whether available maintenance, repair, and replacement service are indicated. The manufacturer shall have a local service agency (within 50 miles of the site) which maintains properly trained personnel and adequate spare parts and is able to respond and complete repairs within 24 hours.
 6. Whether an itemized estimate is included of all costs that will result directly or indirectly from acceptance of such substitution, including cost of redesign and claims of other contractors affected by the resulting change.
 7. Whether the proposed substitute item meets or exceeds the experience and/or equivalency requirements listed in the appropriate technical specifications.
- D. Without any increase in cost to the Owner, the Contractor shall be responsible for and pay all costs in connection with proposed substitutions and of inspections and testing of equipment or materials submitted for review prior to the Contractor's purchase thereof for incorporation in the Work, whether or not the Engineer accepts the proposed substitution or proposed equipment or material. The Contractor shall reimburse the Owner for the charges of the Engineer for evaluating each proposed substitution.

PART 2 -- PRODUCTS (NOT USED)

PART 3 -- EXECUTION (NOT USED)

END OF SECTION

SECTION 01 61 10
EQUIPMENT PRE-PROCUREMENT - GENERAL

PART 1 -- GENERAL

1.1 DEFINITIONS

- A. **PURCHASER:** The entity that is responsible for purchasing the equipment specified herein. The PURCHASER will pay for the equipment and will turn it over to the OWNER upon completion of final payment and acceptance for beneficial use.

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- B. **GENERATOR SUPPLIER:** The entity that is responsible for furnishing the standby generator and generator switchgear to the PURCHASER for installation by the CONTRACTOR.
- C. **PUMP SUPPLIER:** The entity that is responsible for furnishing the three horizontal split-case pumps and motors to the PURCHASER for installation by the CONTRACTOR.
- D. **VFD SUPPLIER:** The entity that is responsible for furnishing four variable frequency drives (VFDs) to the PURCHASER for installation by the CONTRACTOR. Three VFDs will be installed by the CONTRACTOR and one will be reserved as a spare unit.
- E. **SUPPLIERS:** The GENERATOR SUPPLIER, PUMP SUPPLIER, and VFD SUPPLIER.
- F. **PRE-PROCURED EQUIPMENT:** The equipment which will be supplied by the SUPPLIERS listed above.
- G. **CONTRACTOR:** The entity that will receive the pre-purchased equipment from the SUPPLIERS and will be responsible for installing the equipment.
- H. **OWNER:** The City of Warren. Ultimately, the installed equipment will become the property of the OWNER. All Warranties shall be provided in the name of the OWNER.
- I. **ENGINEER:** Stantec. The OWNER's Engineering Representative.
- J. **FURNISH:** "Furnish" means to furnish the equipment only (equipment is installed by a "Contractor").
- K. **INSTALL:** "Install" means to install the equipment only (equipment is furnished by a "Supplier").
- L. **PROVIDE:** "Provide" means to both furnish and install complete, ready for operation.

1.2 SUMMARY OF WORK

EQUIPMENT PRE-PROCUREMENT - GENERAL

- A. Under this Contract, the CONTRACTOR shall receive and install PREPROCURED EQUIPMENT as specified in the Contract Documents. In general, this WORK includes:
 - a. Receive the specified equipment at the project site or project storage location and co-inspect the delivered equipment with the, PURCHASER, OWNER, and ENGINEER.
 - b. Install equipment....

1.2 DELIVERY, UNLOADING, AND ACCEPTANCE

- A. The CONTRACTOR will be responsible for the coordination of the delivery of the equipment by the SUPPLIERS to the project site or project storage location, unloading of the equipment at the project site or project storage location, co-inspection of the equipment upon arrival at the site, notification to the SUPPLIERS of any missing or damaged equipment, storage of the equipment on site until the time of installation, and installing the equipment according to the Contract Documents and the instructions of the SUPPLIERS.
- B. At the time of arrival to the delivery site, the CONTRACTOR, along with the PURCHASER, OWNER, ENGINEER and the SUPPLIERS, shall visually inspect the equipment and note in writing any apparent damage, missing equipment, defects or other deficiencies. All parties shall sign a form indicating the equipment provided to the CONTRACTOR, the date and time of acceptance, any visual defects observed, and the names and signatures of all individuals inspecting and providing/receiving the materials. Any equipment identified as missing or damaged during the inspection shall be furnished and/or replaced by the SUPPLIERS.
- C. The CONTRACTOR will accept and unload the equipment and assume responsibility of the equipment following inspection and signing and will be responsible for properly unloading, storing, and securing the equipment to prevent damage or theft. Handling, and storage will conform to the SUPPLIER's written recommendations.
- D. The CONTRACTOR will protect and maintain the equipment furnished by the SUPPLIERS in a manner that will prevent damage in accordance with the SUPPLIER's instructions and recommendations until final acceptance of the WORK.

1.3 SUBMITTALS

- A. Shop Drawings: Final shop drawings, including storage, handling and installation instructions, will be provided to the CONTRACTOR by the SUPPLIERS for the CONTRACTOR's use in performing the WORK under this Section. These shop drawings are in addition to those required for review and approval as described in in Section 01 33 00 Submittal Procedures.
- B. Operations and Maintenance Manuals: Operations and Maintenance Manuals will be made available to the CONTRACTOR by the SUPPLIERS for the CONTRACTOR's use in performing the WORK under this Section. These manuals are in addition to those required for review and approval as described in in Section 01 33 00 Submittal Procedures.

1.4 QUALITY ASSURANCE

- A. Field Tests: All units shall be field tested after installation to demonstrate satisfactory operations. The CONTRACTOR will coordinate with the SUPPLIERS to review and inspect the installation and complete field testing. The CONTRACTOR will notify the OWNER and SUPPLIERS that equipment is ready for testing a minimum of 10 working days prior to testing.

1.5 WARRANTY

- A. At the completion of installation, the equipment will be turned over from the PURCHASER to the OWNER. The equipment warranty shall be provided in the name of the OWNER. Unless specified for a longer duration in the various equipment specifications, the warranty period shall be not less than 18 months from the date of startup.

PART 2 -- PRODUCTS

2.1 GENERAL

- A. The SUPPLIERS shall furnish the equipment, submittals, manuals, services and appurtenances as specified in the Contract Documents. The SUPPLIERS shall participate in the equipment inspection, startup and testing activities during construction. The SUPPLIERS shall be available to answer questions from the CONTRACTOR, OWNER, PURCHASER and ENGINEER during the contract period.

PART 3 -- EXECUTION

3.1 HANDLING, STORAGE AND INSTALLATION

- A. Instructions for handling the equipment and storage thereof shall be provided by the SUPPLIERS to the CONTRACTOR prior to shipment.
- B. Instructions for installing the equipment and Operations and Maintenance Manuals shall be provided in accordance with Section 01 33 00 – Submittal Procedures.
- C. CONTRACTOR shall install, test, startup and commission equipment in accordance with the specifications, approved submittals and SUPPLIER instructions.

3.2 FIELD TESTING

- A. Following installation, a functional test on all equipment furnished by the SUPPLIERS shall be performed by the SUPPLIERS and the CONTRACTOR in the presence of the OWNER.
- B. Prior to commissioning, all equipment furnished by the SUPPLIERS above shall be performance tested under actual or approved simulated operating conditions in accordance with the Contract Documents. Such testing shall be performed by the SUPPLIERS and the CONTRACTOR and coordinated with the OWNER.

END OF SECTION

SECTION 01 75 00 – EQUIPMENT TESTING AND PLANT STARTUP

PART 1 - GENERAL

1.1 THE SUMMARY

- A. Plant startup is prerequisite to satisfactory completion of the contract requirements and shall be completed within the Contract Times.
- B. Conduct all test, check out, startup, and related requirements indicated in the Contract Documents and provide documentation of same to the ENGINEER prior to requesting Substantial Completion from the ENGINEER. Where manufacturer onsite inspections are required before startup, the manufacturer shall furnish a written statement that the installation and check out is complete and proper and that the item(s) are ready for startup
- C. Startup of a treatment plant is a highly complex operation requiring the combined expertise of the CONTRACTOR, Subcontractors, the ENGINEER, and the OWNER. The CONTRACTOR shall be responsible for coordinating all parties for a successful startup: the ENGINEER and OWNER will be available for technical and operational advice prior to and during startup.
- D. General requirements for startup activities are included in this Section. More specific requirements may also be included in other portions of the Contract Documents.
- E. Temporary facilities may be necessary. If so, CONTRACTOR shall design, provide, operate, and later decommission them.
- F. During startup, product water shall be wasted.

1.2 DEFINITIONS

- A. Startup is defined as testing, demonstrations, and other activities as required to achieve Substantial Completion. Startup includes pre-commissioning and commissioning activities, manufacturer's services, certifications of readiness for testing, and troubleshooting, checkout, and shakedown activities.
- B. Pre-commissioning is the systematic demonstration through testing and extended operation that major equipment and auxiliary systems, including related components, sub-systems, and systems operate properly and consistent with their intended function. Pre-commissioning involves balancing, adjustments, calibration, loop checks, and loop validation. Pre-commissioning shall simulate shutdown conditions, failure conditions, power fail and restart, bypass conditions, and failure resets. Pre-commissioning will not be considered complete until successful results and documentation of tests and manufacturer's certifications required by the Contract Documents are submitted and accepted by the ENGINEER. Pre-commissioning of all portions of the WORK shall be successfully completed prior to starting Commissioning.
- C. Commissioning is the verification that the complete WORK functions on an extended basis in full conformance with the Contract requirements.

1.3 SUBMITTALS

- A. Schedule: The schedule for startup shall be submitted under Section 01 32 14 – Construction Schedule.
- B. Startup Plan: Not less than 60 Days prior to startup, submit for review a detailed Startup Plan. The CONTRACTOR shall revise the Plan as necessary based on review comments. The Plan shall include:
 - 1. Schedules for manufacturers' equipment certifications
 - 2. Schedules for submitting final Technical Manuals,
 - 3. Schedule for training the OWNER's personnel,
 - 4. Description of temporary facilities and schedule for installation and decommissioning them
 - 5. List of OWNER and CONTRACTOR-furnished supplies
 - 6. Detailed schedule of operations to achieve successful pre-commissioning and commissioning.
 - 7. Checklists and data forms for each item of equipment
 - 8. Address coordination with the OWNER's staff.
 - 9. Designate a representative of the CONTRACTOR who has the authority to act in matters relating to startup and has experience in testing large pump stations and pipelines. The Plan shall also designate the roles and responsibilities of any Subcontractors that may be involved in startup activities.
 - 10. Safety, startup, and testing procedures and proposed inspection and certification forms and records.
 - 11. Interconnection of new to existing facilities
 - a. Date and time frame of proposed shutdown or interconnection, including sequence of events and activities to be conducted.
 - b. A detailed description of sequences and activities for the planned shutdown and interconnection.
 - c. Staff, equipment, and materials that will be at the Site before commencing the shutdown.
 - d. Other provisions so that interconnection, testing, and startup will be completed within the planned time.
 - 12. Hydrostatic testing of water-holding structures and pipelines and other potable water equipment. Schedule and plan shall indicate source of water, testing and disinfection sequence, disinfection procedures, and the disposal of the water following disinfection.

- C. System Outage Requests: Request for shutdown of existing systems as necessary to test or start up new facilities.
- D. Records and Documentation
 - 1. Where required by the specifications, submit equipment installation certifications under those Sections.
 - 2. Records of startup as indicated below.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION

3.1 MALFUNCTIONS

- A. During the extended operational demonstrations, all components, subsystems, systems, and equipment must properly run continuously 24 hours per day at rates indicated by the ENGINEER throughout the test period. Unless indicated otherwise, if any item fails or malfunctions during the test, the item shall be repaired and the test restarted at time zero with no credit given for the operating time before the failure or malfunction. Malfunctions satisfying all 3 of the following conditions will allow the demonstration period to resume at the elapsed time when the malfunction started:
 - 1. Malfunction did not cause any interruption of the continuous operation of any other components, subsystems, systems, and equipment.
 - 2. Malfunction was corrected without causing or requiring any components, subsystems, systems, and equipment to cease operations.
 - 3. Malfunction was corrected within one hour of the time the malfunction was detected (the one hour period includes the time required to locate the cause of the malfunction, beginning upon CONTRACTOR's notification from the ENGINEER that a malfunction has occurred and ending when the item is corrected and the system is successfully placed back into operation).
- B. The CONTRACTOR shall arrange for manufacturer's representatives to visit the Site as often as necessary to correct malfunctions.

3.2 PREREQUISITES

- A. Pre-commissioning and commissioning activities shall be scheduled according to Section 01 32 14 –Construction Schedule. The 7 Day demonstrations and the 8 Day demonstration shall start prior to midday on a Monday, Tuesday, or Wednesday. Testing periods shall not include holidays, based on the OWNER's calendar.
- B. The following shall be completed before pre-commissioning begins.
 - 1. All Technical Manual information required by the Contract Documents has been submitted.
 - 2. Safety equipment, emergency shower and eyewash units, fire extinguishers, gas detectors, protective guards and shields, emergency repair kits, safety chains, handrails, gratings, safety signs, and valve and piping identification required by the

Contract Documents are provided. Devices and equipment shall be fully functional, adjusted, and tested.

3. Manufacturer's certifications of proper installation have been accepted.
4. Leakage tests, electrical tests, and adjustments have been completed.
5. The ENGINEER has approved the Startup Plan.
6. Temporary facilities are functional, adjusted, and ready for use.
7. Individual instrumentation loops (analog, status, alarm, and control) have been verified functionally.
8. Pressure switches, flow switches, timing relays, level switches, vibration switches, temperature switches, RTD monitors, pressure regulating valves, and other control devices to the settings determined by the ENGINEER or the equipment manufacturer have been adjusted for accuracy.
9. Individual interlocks between the field-mounted control devices and the motor control circuits, control circuits of variable-speed controllers, and packaged system controls have been verified.

3.3 GENERAL

A. Supplies

1. The CONTRACTOR shall furnish:
 - a. Chemicals
 - b. Fuel
 - c. Oil and grease
 - d. Other necessary materials not listed for the OWNER to furnish
2. The OWNER will furnish:
 - a. Water
 - b. Power

B. Startup Records: The CONTRACTOR shall maintain the following during testing and startup and submit originals to ENGINEER:

1. Lubrication and service records for each mechanical and electrical equipment item
2. Hours of daily operation for each mechanical and electrical equipment item
3. Equipment alignment and vibration measurement records
4. Logs of electrical measurements and tests
5. Instrumentation calibration and testing logs

6. Testing and validation of SCADA inputs, outputs, logic functions, status indications, and alarms
7. Factory and field equipment settings
8. Log of problems encountered and remedial action taken
9. Other records, logs, and checklists as required by the Contract Documents

3.4 PRE-COMMISSIONING

- A. After individual equipment items and subsystems have been tested and certified as required by the Technical Specifications, tests of systems comprised of single or multiple equipment items with appurtenant equipment and instruments and controls shall be conducted. Items of equipment shall be tested as part of a system to the maximum extent possible.
- B. Subject to the malfunction criteria above, each system shall be demonstrated for a continuous, 7 Day, 24 hour/day period. If any system malfunctions, the item or equipment shall be repaired and the test restarted at time zero with no credit given for the elapsed time before the malfunction.
- C. The CONTRACTOR shall demonstrate the manual and automatic modes of operation to verify proper control sequences, software interlocks, proper operation of software logic and controllers, etc. System testing shall include the use of water or other process media, as applicable, to simulate the actual conditions of operation.
- D. Systems testing activities shall follow the detailed procedures and checklists in the Testing and Startup Plan. Completion of systems shall be documented by a report.
- E. The CONTRACTOR shall demonstrate utility, chemical feed, safety equipment, and other support systems before whole process systems.
- F. Furnish the ENGINEER at least 10 Days written notice confirming the start of pre-commissioning. The OWNER's staff will observe pre-commissioning

3.5 COMMISSIONING

- A. The CONTRACTOR shall start up the plant and operate it without malfunction for a continuous 8 Day, 24 hour/day period. The ENGINEER will determine the operational parameters.
- B. Defects that appear shall be promptly corrected. Time lost for wiring corrections, control point settings, or other reasons that interrupt the test may, at the judgement of the ENGINEER, be cause for extending the demonstration an equal amount of time.
- C. Commissioning shall not begin until leakage tests, instrumentation tests and adjustments, electrical tests and adjustments, equipment field tests, disinfection and system tests have been completed to the satisfaction of the ENGINEER.
- D. During commissioning, the CONTRACTOR shall:
 1. Lubricate and maintain equipment in accordance with the manufacturers' recommendations.

2. Clean or replace strainers, screens, and filter elements.

END OF SECTION

SECTION 01 77 00– PROJECT CLOSEOUT

PART 1 -- GENERAL

1.01 FINAL CLEANUP

- A. The Contractor shall promptly remove from the vicinity of the completed Work, all rubbish, unused materials, concrete forms, construction equipment, and temporary structures and facilities used during construction. Final acceptance of the Work by the Owner will be withheld until the Contractor has satisfactorily performed the final cleanup of the Site.

1.02 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

- A. Reference Specifications

01 33 00	Submittal Procedures
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1.03 CLOSEOUT TIMETABLE

- A. The Contractor shall establish dates for equipment testing, acceptance periods, and on-site instructional periods (as required under the Contract). Such dates shall be established not less than one week prior to beginning any of the foregoing items, to allow the Owner, the Engineer, and their authorized representatives sufficient time to schedule attendance at such activities.

1.04 TECHNICAL MANUAL SUBMITTAL

- A. The Contractor's attention is directed to the condition that one percent of the Contract Price will be retained from any monies due the Contractor as progress payments, if at the 75 percent construction completion point, the approved Technical Manual complying with Section 01 33 00 – Submittal Procedures has not been submitted. The aforementioned amount will be retained by the Owner as the agreed, estimated value of the approved Technical Manual. Any such retention of money for failure to submit the approved Technical Manual on or before the 75 percent construction completion point shall be in addition to the retention of any payments due to the Contractor under Article 15 of the General Conditions.

1.05 FINAL SUBMITTALS

- A. The Contractor, prior to requesting final payment, shall obtain and submit the following items to the Engineer for transmittal to the Owner:
1. Written guarantees, where required.
 2. Technical Manuals and instructions.
 3. New permanent cylinders and key blanks for all locks.
 4. Maintenance stock items; spare parts; special tools.
 5. Completed record drawings.

6. Bonds for roofing, maintenance, etc., as required.
7. Certificates of inspection and acceptance by local governing agencies having jurisdiction.
- B. Evidence of payment and release of liens in accordance with conditions of the Contract.
- C. Consent of Surety to final payment.
- D. Releases from all parties who are entitled to claims against the subject project, property, or improvement pursuant to the provisions of law.

1.06 MAINTENANCE AND GUARANTEE

- A. The Contractor shall comply with the maintenance and guarantee requirements contained in the General Conditions.
- B. Replacement of earth fill or backfill, where it has settled below the required finish elevations, shall be considered as a part of such required repair work, and any repair or resurfacing constructed by the Contractor which becomes necessary by reason of such settlement shall likewise be considered as a part of such required repair work unless the Contractor shall have obtained a statement in writing from the affected private owner or public agency releasing the Owner from further responsibility in connection with such repair or resurfacing.
- C. The Contractor shall make all repairs and replacements promptly upon receipt of written order from the Owner. If the Contractor fails to make such repairs or replacements promptly, the Owner reserves the right to do the Work and the Contractor and its surety shall be liable to the Owner for the cost thereof.

1.07 BOND

- A. The Contractor shall provide a bond to guarantee performance of the provisions contained in Paragraph "Maintenance and Guarantee" above, and the General Conditions.

PART 2 -- PRODUCTS (NOT USED)

PART 3 -- EXECUTION (NOT USED)

END OF SECTION

SECTION 01 78 36– WARRANTIES

PART 1 -- GENERAL

1.01 REQUIREMENTS INCLUDED

- A. Preparing and submitting of warranties and bonds.

1.02 FORM OF SUBMITTALS

- A. Electronic PDFs.
- B. Label cover of each binder with typed or printed title "WARRANTIES AND BONDS", with title of Project; name, address and telephone number of Contractor; and name of responsible principal.
- C. Table of Contents: Neatly typed, in the sequence of the Table of Contents of the Contract Documents, with each item identified with the number and title of the specification section in which specified, and the name of product or work item.
- D. Separate each warranty or bond with index tab sheets keyed to the Table of Contents listing. Provide full information, using separate typed sheets as necessary. List subcontractor, supplier, and manufacturer, with name, address, and telephone number of responsible principal.

1.03 PREPARATION OF SUBMITTALS

- A. Obtain warranties and bonds, executed in duplicate by responsible subcontractors, suppliers, and manufacturers within ten (10) days after completion of the applicable item of work. Except for items put into use with Owner's permission leave date of beginning of time of warranty open until the date of substantial completion is determined. All warranty coverage shall be extended directly to the benefit of the Owner.
- B. Verify that documents are in proper form, contain full information, and are notarized.
- C. Co-execute submittals when required.
- D. Retain warranties and bonds until time specified for submittal.

1.04 TIME OF SUBMITTALS

- A. For equipment or component parts of equipment put into service during construction with Owner's permission, submit documents within ten (10) days after acceptance.
- B. Make other submittals within ten (10) days after date of substantial completion, prior to final application for payment.
- C. For items of Work when acceptance is delayed beyond date of substantial completion, submit within ten (10) days after acceptance, listing the date of acceptance as the beginning of the warranty period.

PART 2 -- PRODUCTS (NOT USED)

PART 3 -- EXECUTION (NOT USED)

END OF SECTION

SECTION 01 79 00 - OWNER STAFF TRAINING

PART 1 - GENERAL

1.1 THE SUMMARY

- A. The CONTRACTOR shall furnish all labor, materials, equipment, and incidentals necessary to train OWNER's personnel on the equipment, products, and systems furnished under this Contract. OWNER training is a prerequisite to satisfactory completion of the Contract requirements and shall be completed within the Contract Time.
- B. The minimum onsite training requirements for various plant components are described in various sections of the specifications.
- C. Except where otherwise indicated, all costs for training shall be the responsibility of the CONTRACTOR.

1.2 SUBMITTALS

- A. Training Schedule: Schedule for training the OWNER's personnel shall be submitted with the detailed Testing and Startup Plan required by Section 01 75 00 – Equipment Testing and Plant Startup.
- B. Resumes of instructors.
- C. Approved operation and maintenance manuals shall be available at least 30 days prior to the scheduled date for the individual training session.
- D. Training classes shall be scheduled a minimum of four (4) weeks in advance of the date of the first class to allow OWNER staffing arrangements to take place
- E. Training classes shall be organized in conjunction with the Startup Systems, as defined in Section 01 75 00 – Equipment Testing and Plant Startup. Each training class shall consist of a classroom portion and a field tour portion. Each training class shall include:
 - 1. Safety to be conducted by the plant safety officer.
 - 2. Overview of the startup system.
 - 3. Training on each item of equipment within the startup system, conducted by the Equipment Manufacturer's representative.
 - 4. Training on the mechanical piping system within the startup system, conducted by the CONTRACTOR'S mechanical superintendent.
 - 5. Training on the power distribution system within the startup system, conducted by the CONTRACTOR'S electrical superintendent.

6. Training on the instrumentation and control systems within the startup system, conducted by the CONTRACTOR'S I&C System Supplier.
 7. Training on the SCADA control system within the startup system.
- F. Class Agenda: A class agenda shall be prepared by the CONTRACTOR and submitted to the ENGINEER with the training schedule. The agenda shall include a listing of subjects to be discussed, time estimated for each subject, a list of documentation to be used and provided to support training, the proposed route of the field tours, and the instructor(s) name and qualifications. Agendas shall include an allocation of time for all components of the training session, including time for OWNER staff to ask questions and discuss the subject matter. The OWNER may request that particular subjects are emphasized and the agenda shall be adjusted to accommodate these requests. Copies of the agenda shall be distributed to each student at the beginning of each training class.
- G. Within ten (10) days after the completion of each training session, the CONTRACTOR shall submit the following:
1. A sign-in sheet of all personnel that attended the training session.
 2. A copy of the training materials utilized during the lesson with all notes, diagrams, and comments.
 3. Files containing the above information and a video of the training.
- 1.3 INSTRUCTOR QUALIFICATIONS
- A. Instructors shall be completely knowledgeable in the products and systems for which they are providing training, and shall be experienced in conducting classes. Sales representatives are not considered qualified instructors unless they possess the detailed operating and maintenance knowledge required for proper class instruction.
- B. Instructor shall have at least two years of experience in providing training certified by the Manufacturer.
- C. If, in the opinion of the OWNER, the Instructor did not provide the scheduled training, such training shall be rescheduled and repeated with a suitable instructor at the CONTRACTOR's expense.

PART 2 - PRODUCTS

2.1 GENERAL

- A. Where specified, the CONTRACTOR shall conduct training sessions for the OWNER's personnel to instruct the staff on the proper operation, care, and maintenance of the equipment and systems installed under this Contract.

2.2 TRAINING AIDS

- A. Each instructor is encouraged to use audio-visual devices, P&IDs, models, charts, or other means to effectively increase the transfer of knowledge. The instructor conducting the training shall furnish all such equipment (televisions, CD/DVD recorder/player, projectors, screens easels, etc.), models, and charts for each class. It shall be the

responsibility of the instructor to confirm in advance that the class room will be appropriate for the types of audio-visual equipment to be employed.

2.3 FORMAT AND CONTENT

A. Each training session shall be comprised of time spent both in the classroom and at the specific location of the subject equipment or system. As a minimum, training session shall cover the following subjects for each item of equipment or system:

1. Familiarization

- a. Review catalog, parts lists, drawings, etc., which have been previously provided for the OWNER's files and operation and maintenance manuals.
- b. Inspection on how the equipment has been installed. Demonstrate the operation of the unit and describe how all parts of the equipment meet the requirement of the Specifications.
- c. Answer questions.

2. Safety

- a. Using material previously provided, review safety features of the equipment.
- b. Discuss proper precautions when working around equipment.

3. Operation

- a. Using material previously provided, review reference literature.
- b. Explain all modes of operation (including emergency).
- c. Check out OWNER's personnel on proper use of the equipment.

4. Preventive Maintenance

- a. Using material previously provided, review preventive maintenance (PM) lists including:
 - 1) Reference material.
 - 2) Daily, weekly, monthly, quarterly, semiannual, and annual PM activities.
- b. Demonstrate how to perform Preventive Maintenance procedures.
- c. Demonstrate to the OWNER's personnel what to look for as indicators of potential equipment problems.

5. Corrective Maintenance

- a. Identify possible problems.
- b. Demonstrate how to perform repairs. Point out special problems.

- c. Open up equipment and demonstrate O & M procedures, where practical.
- 6. Parts
 - a. Demonstrate the use of previously provided parts list and order parts.
 - b. Check over spare parts on hand. Make recommendations regarding additional parts that should be available.
- 7. Local Representatives
 - a. Identify local vendors where to order parts: name, address, telephone.
 - b. Service problems:
 - 1) Identify contacts local contacts.
 - 2) Identify emergency contacts.
- 8. Operation and Maintenance Manuals
 - a. Review any other material submitted.
 - b. Update material, as required.

PART 3 - EXECUTION

3.1 GENERAL

- A. The objective of the training included under this Section shall be to convey the knowledge needed by the OWNER operations, maintenance, and engineering staff to safely operate, maintain, and repair the equipment and systems furnished under this CONTRACT.
- B. OWNER personnel who will participate in this training have existing full-time work assignments and this training is an additional assigned work task. OWNER's staff work schedules regularly shift, as the plant is operated on an around-the-clock basis.
- C. Training shall be tailored to suit the skills and job classifications of the personnel attending the classes e.g., plant manager, plant operator, maintenance technical, electrician, etc.
- D. Minimum onsite training requirements for plant components are described in various sections of the Specifications. For the purpose of the times given in individual Specification sections, a workday is defined as an eight (8) hour day at the site, excluding travel time.
- E. Training shall be scheduled as a separate trip from equipment inspection, startup, and field adjustment. Training shall not be done until the manufacturer certifies that the equipment is operable as specified.
- F. Specific Training Objectives: The training shall include a review of the equipment and drives, including internal parts, as prepared at the factory. The training shall include

safety, removal, inspection, cleaning, operation and maintenance of the equipment such as startup, normal operation and shutdown procedures, step-by-step troubleshooting procedures with all necessary test equipment, and emergency or abnormal operation procedures. Training shall include preventive maintenance and long-term maintenance procedures, special tools necessary, and a discussion of recommended spare parts.

3.2 TRAINING CLASSES

- A. Number of Classes on Each Subject: A minimum of two (2) classes on identical subject matter shall be conducted, unless otherwise indicated. The purpose of having two (2) classes on each subject is to accommodate the attendance of as many OWNER personnel working different shifts as possible
- B. A maximum of one (1) class per day shall be held on consecutive days unless otherwise approved by the OWNER. Multiple classes may be scheduled if the class duration is shorter than four (4) hours. Times shall be scheduled at the discretion of the OWNER.
- C. Class Length: Each class shall be subdivided into two (2) to six (6) hour modules, or as appropriate for the subject matter being discussed.
- D. Number of Students: It is estimated that five (5) to ten (10) persons will attend each training class. The OWNER will determine the actual number of students. Provide training materials for all attendees.
- E. Cancellation of Classes: If a class must be canceled because the equipment is not ready for operation, etc. the CONTRACTOR shall notify the OWNER at least one (1) week in advance. The CONTRACTOR shall coordinate with the OWNER to reschedule the training.

3.3 TRAINING AIDS

- A. Training Aids: Each instructor is encouraged to use audio-visual devices, P&IDs, models, charts, etc. to increase the transfer of knowledge. The CONTRACTOR shall provide all such equipment (televisions, videocassette recorder/player, projectors, screens, easels, models, charts, etc.) for each class. It shall be the responsibility of the CONTRACTOR to confirm in advance that the training room set-up will be appropriate for the types of audiovisual equipment to be employed.
- B. Classroom Documentation: If training is being completed on equipment, systems, or products for which a Technical Manual is required, the draft Technical Manual shall have been returned by the ENGINEER with a status of "No Exceptions Taken" or "Make Corrections Noted" before the training class is scheduled. The approved Technical Manual shall be used during the classroom instruction. Supplemental documentation handouts shall be provided by the organization conducting the training as required to the support instruction.

3.4 DOCUMENTATION OF TRAINING

- A. The CONTRACTOR shall videotape the entire detailed training course in proper operation and maintenance and provide the video. The video shall be organized by each segment of the training session and be presented in a table of contents style with selectable segments of the session. The video shall become the exclusive property of

the OWNER. The OWNER reserves the right to videotape, photograph, audio record, and otherwise document any or all training classes provided under this WORK.

B. The following services shall be provided for each item of equipment or system as required in individual specification sections. Additional services shall be provided, where specifically required in individual specification sections.

1. As a minimum, classroom equipment training for operations personnel will include:
 - a. Identify and discuss safety items and procedures.
 - b. Using slides and drawings, discuss the equipment's specific location in the plant and an operational overview.
 - c. Purpose and plant function of the equipment.
 - d. A working knowledge of the operating theory of the equipment.
 - e. Start-up, shutdown, normal operation, and emergency operating procedures, including a discussion on system integration and electrical interlocks, if any.
 - f. Routine preventative maintenance, including specific details on lubrication and maintenance of corrosion protection of the equipment and ancillary components.
 - g. Operator detection, without test instruments, of specific equipment trouble symptoms.
 - h. Required equipment exercise procedures and intervals.
 - i. Routine disassembly and assembly of equipment if applicable (as judged by the OWNER on a case-by-case basis) for purposes such as operator inspection of equipment.
2. As a minimum, hands-on equipment training for operations personnel will include:
 - a. Identify and review safety items and perform safety procedures.
 - b. Identify location of equipment and review the purpose.
 - c. Identifying piping and flow options.
 - d. Identifying valves and their purpose.
 - e. Identifying instrumentation:
 - f. Location of primary element.
 - g. Location of instrument readout.
 - h. Discuss purpose, basic operation, calibration, maintenance, troubleshooting, repair, and information interpretation.

- i. Discuss, demonstrate, and perform standard operating procedures and round checks.
 - j. Discuss and perform the preventative maintenance activities.
 - k. Discuss and perform start-up and shutdown procedures.
 - l. Perform the required equipment exercise procedures.
 - m. Perform routine disassembly and assembly of equipment if applicable.
3. Classroom equipment training for the maintenance and repair personnel will include:
- a. Safety procedures.
 - b. Theory of operation.
 - c. Description and function of equipment.
 - d. Start-up and shutdown procedures.
 - e. Normal and major repair procedures.
 - f. Equipment inspection and troubleshooting procedures including the use of applicable test instruments and the "pass" and "no pass" test instrument readings.
 - g. Routine and long-term calibration procedures.
 - h. Preventative maintenance such as lubrication; normal maintenance such as belt, seal, and bearing replacement; and up to major repairs such as replacement of major equipment part(s) with the use of special tools, bridge cranes, welding jigs, etc.
 - i. Hands-on equipment training for maintenance and repair personnel shall include:
 - 1) Locate and identify equipment components.
 - 2) Review the equipment function and theory of operation.
 - 3) Review normal repair procedures.
 - 4) Perform start-up and shutdown procedures.
 - 5) Review and perform the safety procedures.
 - 6) Perform OWNER-approved practice maintenance and repair job(s), including mechanical and electrical adjustments and calibration and troubleshooting equipment problems.

END OF SECTION

SECTION 02 21 13 – SITE SURVEYS

PART 1 -- GENERAL

1.01 THE SUMMARY

- A. The Contractor shall conduct a thorough pre-construction and post-construction Site Condition Survey of the entire Project. Site Condition Survey shall consist of photographs, video recordings, and topographic mapping.

1.02 CONTRACTOR SUBMITTALS

- A. Video surveys, photographs, and other data of the preconstruction conditions shall be submitted to the Engineer for record purposes prior to, but not more than 30 days before, commencement of any construction activities.
- B. Except as otherwise indicated, post-construction topographic mapping shall be submitted to the Engineer within 60 days of completing Work.
- C. A complete set of all photographs, video, and survey data of the post-construction conditions shall be completed and submitted by the Contractor prior to final inspection by the Owner and Engineer.

1.03 PRECONSTRUCTION PHOTOGRAPHS AND VIDEOS

- A. Prior to commencing the Work, the Contractor shall provide a continuous color digital audio-video recording, MP4 video format, delivered on a standard USB flash drive, or as otherwise approved by the Owner.
- B. The Contractor shall provide one copy of the pre-construction video to the Owner, one copy to the Engineer, and maintain one copy free from damage or defect that shall become the property of Owner at Project Close Out. The Contractor shall review the video recordings for clarity and accuracy and shall make supplemental records of existing conditions if they are not clearly indicated.
- C. No construction shall begin prior to review of the preconstruction video of the construction area by the Owner, Engineer and the Contractor. The Engineer or Owner shall have the authority to reject all or any portion of the video not conforming to specifications and order that it be redone at no additional charge to the Owner. The Contractor shall reschedule unacceptable coverage within five (5) calendar days after being notified. The Engineer shall designate those areas, if any, to be omitted from or added to audio-video coverage.
- D. Video recording shall be made not more than 30 days prior to commencement of construction.
- E. The Contractor shall video the entire project area including the project site, and any other areas which may be affected or impacted by the Work including staging and storage areas.

- F. The Contractor shall supplement video recordings with photographs. A minimum of twenty (20) pre-construction photographs shall be provided for each work area.

1.04 CONSTRUCTION PROGRESS PHOTOGRAPHS

- A. A minimum of ten (10) photographs of each work area shall be taken each week until completion of the Work.
- B. The number of photographs required shall be at the sole discretion of the Engineer whose decision shall be final. An increase in the number of photographs above the minimum shall not be cause for an increase in cost and no extra compensation will be allowed.
- C. For all photographs, the Contractor shall coordinate with the Engineer as to the actual number and location of views to be photographed and the day and time of photographing.
- D. Progress photographs shall be submitted with monthly Applications for Payment in accordance with the Contract Documents.

1.05 POST-CONSTRUCTION PHOTOGRAPHS AND VIDEO

- A. At project closeout, the Contractor shall provide one (1) continuous color digital audio-video recording of the entire area of the project to serve as a record of the post-construction conditions. The completed project area and adjacent properties shall be captured.
- B. The post-construction video recording shall be supplemented with a minimum of forty (40) photographs documenting the completion of the project construction and adjacent properties.

1.06 QUALITY ASSURANCE

- A. Color audio-video taping must be compiled by a professional photographer actively engaged in color audio-video recordings of similar type projects. The names of the companies and additional requested information must be submitted to the Owner for approval prior to engaging the companies proposed to perform the preconstruction videotaping.
- B. Photography must be compiled by a professional photographer actively engaged in taking pictures of similar type projects. The names of the companies and additional requested information must be submitted to the Owner for approval prior to engaging the companies proposed to perform the preconstruction photography.
- C. Photographs and video shall be clear and sufficient to show significant detail, not blurred, or taken in shadow, nor too distant. The Owner may require that the photographs or video be retaken should the quality be insufficient. Costs for such re-takes are the Contractor's responsibility at no extra cost to the Owner.

PART 2 -- PRODUCTS

2.01 VIDEO MEDIA

- A. The video portion of the recording shall produce bright, sharp, and clear pictures with accurate colors and shall be free from distortion, tearing, rolls, and any other form of picture imperfection.
- B. All video recordings shall contain coverage of all surface features located within the construction zone of influence. Of particular concern shall be the existence of any faults, fractures, defects, etc. of existing features, particularly those located at private properties and homes immediately adjacent to and across the street from the project site. Panning, zoom-in and zoom-out rates shall be sufficiently controlled to maintain a clear view of the object.
- C. All video recordings shall, by electronic means, display continuously and simultaneously, the date and time of recording. The video recording shall be generated with the actual taping date and time as transparent digital information. The date information shall contain the month, day and year. The time information shall consist of hours, minutes and seconds.
- D. Video media shall be MP4 video format delivered on USB flash drive, or as otherwise approved by the Owner.
- E. Accompanying the video recording shall be a corresponding and simultaneously recorded audio recording. Each tape shall begin with the recorded date, project name and be followed by the general location, i.e., viewing side and direction of progress. The audio track shall consist of an original live recording. The recording shall contain exclusively the narrative commentary of the electrographer, recorded simultaneously with the fixed elevation video record of the zone of influence of construction. The recording shall assist in viewer orientation and in any needed identification, differentiation, clarification, or objective description of the features being shown in the video portion of the recording, including location relative to construction stations. The audio recording shall be free from any conversations between the camera operator and any other production technicians. The audio portion of the recording shall produce the commentary of the camera operator with proper volume, clarity, and be free from distortion and interruptions.

2.02 VIDEO MEDIA INDEXING

- A. Video Identification: All video media shall be permanently labeled and shall be properly identified by number and project name and location.
- B. Video Logs: Each video shall have a log of that video's contents. The log shall describe the various segments of coverage contained on the video in terms of the names of the streets or easements, coverage beginning and end, directions of coverage, video unit counter numbers, and date.
- C. Video Index: The electrographer shall provide an index listing, in order by video number, each video number and a brief description of coverage contained on that

video, including engineering station numbers and/or street address at every building abutting roadway and canal.

2.03 PHOTOGRAPHS

- A. Furnish one (1) flash drive in electronic JPG format.
- B. Photographs shall have a minimum clarity of 5 megapixels.

PART 3 -- EXECUTION

3.01 PHOTOGRAPHS AND VIDEO RECORDINGS

- A. Contractor, at a minimum, shall document pre- and post-construction conditions by preparing video surveys of the following:
 - 1. Roadways used to access the Site or haul materials and equipment to the Site.
 - 2. Work areas, including actual work sites, materials processing and stockpiling areas, access corridors, disposal areas, and staging areas.
 - 3. Any work completed by other contractors at the Site that will be connected to or otherwise affected by the Work.
 - 4. Driveways, sidewalks, and buildings which might be affected by the Work.
- B. Supplement video surveys with photographs and spot elevation surveys as required to thoroughly document the original condition and location of existing features and facilities.
- C. Video records shall provide a continuous color digital audio-video recording of the entire area of the project to serve as a record of the site pre-construction conditions.

3.02 TOPOGRAPHIC MAPPING SURVEY

- A. Topographic mapping shall be developed using the Project coordinates, shall be referenced to the Project base lines and benchmarks, and shall be adequate to ascertain pre-construction and post-construction elevations of all public and private property within and adjacent to the construction limits
- B. Topographic mapping shall be conducted to document the post-construction topography of the Site. The Contractor shall sufficiently capture the existing pre-construction conditions within the project site, but not limited to: staging areas, work areas, roadways, light poles, trees, landscaping, storm drainage structures, walls, and any other areas which may be affected or impacted by the Work to protect the Owner, the Engineer, and the Contractor from unsubstantiated claims. The Contractor shall capture existing deterioration of landscaping and other fixtures and features in or adjacent to the area of Work, whether impacted or not.

- C. Spot elevation surveys used to document the elevation on abutting roadways, drives, and walks shall be taken at approximately 20-foot intervals and at the point of juncture with any structure to which they are attached or otherwise influenced by the Work.
- D. All pre- and post-construction topographic mapping and other data, including spot elevations, shall be prepared and sealed by a Professional Land Surveyor.
- E. All pre- and post-construction survey data shall be furnished as follows:
 - 1. Site mapping shall be submitted as a separate electronic drawing in AutoCAD 2015, or later.
 - 2. Each AutoCAD site map shall also be submitted in hard copy plot format (one (1) copy).
 - 3. Engineer will review hardcopy plots for accuracy relative to the indicated requirements.
 - 4. Contractor shall amend mapping files as required, based on Engineer's comments.
 - 5. The electronic mapping files shall be produced using field survey techniques with sufficient accuracy for reproduction and use as base maps at a scale of 1"=20' horizontal and 1-foot contour intervals
 - 6. Electronic mapping files shall be three-dimensional.
 - 7. Submit point lists for all topographic surveys in .csv file format.
 - 8. All files shall be copied to one or more USB drives in a format acceptable by the Owner.
 - 9. Submit two (2) copies of the USB drives.

END OF SECTION

SECTION 02 41 00 – DEMOLITION

PART 1 -- GENERAL

1.01 SUMMARY

- A. The Contractor shall provide all labor, materials, equipment and incidentals as shown, specified and required for demolitions of existing civil, landscaping, structural, architectural, mechanical, HVAC, electrical, and instrumentation facilities as indicated, in accordance with the Contract Documents.

1.02 COORDINATION

- A. The Contractor shall carefully coordinate the Work in areas where existing facilities are interconnected with new facilities and where existing facilities remain operational. The Work as indicated is not all-inclusive, and the Contractor shall be responsible to perform the reconstruction indicated plus that which can be reasonably inferred from the Contract Documents as necessary to complete the Project. The Specifications and Drawings identify the major facilities that shall be demolished and reconstructed, but auxiliary utilities such as water, air, chemicals, drainage, lubrication, fluid power, electrical wiring, controls, and instrumentation are not necessarily shown. The Contractor shall comply with sequencing requirements in Section 01 14 00 - Construction Restraints.
- B. The Contractor shall note that the Drawings used to indicate demolition and reconstruction are based on survey of surface features, record information, site photographs, other provided describing the existing facilities. The record information has been reproduced in the Drawings to show existing conditions and to clarify the scope of Work. The information provided may not be complete or accurate. The Contractor shall conduct a comprehensive survey at the Site to verify the correctness and exactness of the Drawings, the scope of Work, and the extent of auxiliary utilities.
- C. While demolition and reconstruction are being performed, the Contractor shall provide adequate access for the continued operation and maintenance of equipment and treatment processes. The Contractor shall erect and maintain fences, warning signs, barricades, and other devices around the reconstruction as required for the protection of the Contractor's employees and the Owner's personnel at the plant. The Contractor shall remove such protection when reconstruction activities are complete, or as Work progresses, or when requested by the Engineer.
- D. The Contractor shall be responsible for acquiring appropriate necessary permits for the work. Copies of the permits shall be submitted to the Owner prior to commencement of demolition.

1.03 CONTRACTOR SUBMITTALS

- A. A demolition plan shall be submitted to the Engineer for review. The demolition plan shall detail demolition and reconstruction activities and procedures, including operational sequences, in accordance with Section 01 33 00 – Submittal Procedures. The procedures shall provide for safe conduct of the Work, careful removal and disposition of materials and equipment, protection of existing facilities which are to remain undisturbed, coordination with existing facilities to remain in service, and timely disconnection and reconnection of utility services. The procedures shall include a detailed description and time schedule of the methods and equipment to be used for each operation and the sequence of operation.

DEMOLITION

- B. The demolition plan shall include identification of items to be salvaged or relocated. A storage plan for salvaged items shall be included.
- C. The Engineer's review shall be limited to a review of the scope and intent of demolition as required by the contract documents. The Contractor shall be responsible for the means and methods to ensure the work is conducted in a safe and proper manner. The Engineer's review of the demolition plan shall in no way alleviate the Contractor from this responsibility.
- D. Protection:
1. Perform all demolition and removal Work to prevent damage or injury to structures, occupants thereof and adjacent features which might result from falling debris or other causes, and so as not to interfere with the use, and free and safe passage to and from adjacent structures.
 2. Closing or obstructing of roadways, sidewalks, and passageways adjacent to the Work by the placement or storage of materials will not be permitted, and all operations shall be conducted with a minimum interference to traffic on these ways.
 3. Erect and maintain barriers, lights, sidewalk sheds, and other necessary protective devices.
 4. Repair damage to facilities to remain, or to any property belonging to the Owner or occupants of the facilities.
- E. Scheduling:
1. Carry out operations to avoid interference with Owner's operations and Work in the existing facilities.
- F. Notification:
1. At least forty-eight (48) hours prior to commencement of a demolition or removal activity, notify the Engineer in writing of the proposed schedule. The Owner will inspect the existing equipment and mark for identification those items which are to remain the property of the Owner. Do not start removals without the permission of the Engineer.
- G. Explosives:
1. Do not bring explosives onto site.
 2. The use of explosives will not be permitted.

1.04 REFERENE SPECIFICATIONS, CODES, AND STANDARDS

A. Reference Specifications

01 14 00	Construction Restraints
01 33 00	Submittal Procedures
01 50 10	Protection of Existing Facilities

1.05 DEMOLITION

- A. Existing pavement, structures, equipment, piping, valves, ductwork, electrical gear, instrumentation, utilities, and related appurtenances such as anchors, supports, and hardware indicated or required to be demolished as part of the Work shall be removed and disposed of unless otherwise indicated. Removal of buried structures, utilities, and appurtenances includes the related excavation and backfill as required. Removed items shall be disposed of offsite by the Contractor.

1.06 SALVAGE

- A. Items of existing equipment, piping, valves, electrical gear, instrumentation, utilities, and appurtenances indicated to be salvaged shall be removed without any degradation in condition from that prior to removal. Salvaged items shall be stockpiled and protected on the Site at a location chosen by the Engineer. The Contractor shall be responsible to properly safeguard the salvaged items against damage and loss during removal and handling.

1.07 RELOCATION

- A. Items of existing equipment, piping, valves, electrical gear, instrumentation, utilities, and appurtenances to be relocated shall be removed without any degradation in condition from that prior to removal. The Contractor shall be responsible to properly safeguard the relocated items against damage and loss during removal, handling, storage, and installation in the new location.

1.08 ABANDONMENT

- A. Items of existing equipment, piping, valves, electrical gear, instrumentation, utilities, and appurtenances to be abandoned shall be prepared by the Contractor as indicated.

1.09 REHABILITATION

- A. Existing civil, landscaping, structural, architectural, mechanical, HVAC, electrical, and instrumentation Work disturbed or damaged by reconstruction activities shall be repaired and rehabilitated as indicated.
- B. Damaged items shall be repaired or replaced with new items to restore items or surfaces to a condition equal to and matching that existing prior to damage.
- C. In buildings with reconstruction Work, the Contractor shall not use any Owner equipment (e.g., bridge cranes and monorails) unless authorized in advance in writing by the Engineer. Such authorization shall be subject to documentation by the Contractor of the proposed load on the equipment and be subject to Owner requirements for usage on operating and maintenance needs. Any damage to a crane shall be repaired or replaced to the Engineer's satisfaction.

1.10 DISPOSAL

- A. The Contractor shall be responsible for the offsite disposal of debris resulting from reconstruction in compliance with local, state, and federal codes and requirements.

PART 2 -- PRODUCTS -- [NOT USED]

PART 3 -- EXECUTION

3.01 GENERAL

- A. The Contractor shall coordinate demolition and reconstruction Work with the Owner and Engineer. Unless otherwise indicated, the Contractor shall be responsible for the sequence of activities. Work shall be performed in accordance with applicable safety rules and regulations.
- B. The Contractor shall verify that any utilities connected to structures, equipment, and facilities to be removed, relocated, salvaged, replaced, or abandoned are rendered inoperable, replaced with new utilities, or adequately bypassed with temporary utilities before proceeding with demolition and reconstruction.
- C. The Contractor shall take precautions to avoid damage to adjacent facilities and to limit the Work activities to the extent indicated. If reconstruction beyond the scope indicated is required, the Contractor shall obtain approval from the Engineer prior to commencing.

3.02 PROTECTION OF EXISTING FACILITIES

- A. Before beginning any reconstruction, the Contractor shall carefully survey the existing facilities and examine the Specifications and Drawings to determine the extent of reconstruction and coordination with the Work. Existing facilities not subject to reconstruction shall be protected and maintained in accordance with Section 01 50 10 - Protection of Existing Facilities. Damaged existing facilities shall be repaired to the previous condition or replaced.
- B. Persons shall be afforded safe passages around areas of demolition.
- C. Structural elements shall not be overloaded. The Contractor shall be responsible for shoring, bracing, or adding new supports as may be required for adequate structural support as a result of Work performed under this Section. The Contractor shall remove temporary protection when the Work is complete or when so authorized by the Engineer.
- D. The Contractor shall carefully consider bearing loads and capacities before placement of equipment and material on Site. In the event of any questions as to whether an area to be loaded has adequate bearing capacity, the Contractor shall consult with the Engineer prior to the placement of such equipment or material.
- E. The Contractor shall promptly repair damages caused to adjacent facilities by demolition operations at no cost to the Owner.

3.03 DEMOLITION, SALVAGE, AND RELOCATION

- A. The Contract Documents indicate existing facilities to be demolished, salvaged, and/or relocated. Auxiliary utilities including such services as water, air, chemicals, drainage, lubrication, fluid power, electrical wiring, controls, and instrumentation are not necessarily indicated. The Contractor shall verify the scope of the Work to remove the equipment indicated; coordinate its shutdown, removal, replacement, or relocation; and submit an outage plan in accordance with Section 01 14 00 - Construction Restraints. The removal of existing facilities for demolition, salvage, and relocation shall include the following requirements:
1. Equipment supports, including concrete pads, baseplates, mounting bolts, and support hangers, shall be removed. Damage to the existing structure shall be repaired as indicated.
 2. Exposed piping including vents, drains, and valves shall be removed. Where exposed piping penetrates existing floors and walls, the piping, including wall thimbles, shall be removed to a minimum depth of 2-inches. Resultant openings in the structure shall be repaired as indicated.
 3. Electrical control panels, junction boxes, motor control centers, and local switches and pushbuttons shall be removed.
 4. Exposed electrical conduits and associated wiring shall be removed. Resultant openings in structures shall be repaired as indicated.
 5. Connections to embedded electrical conduits shall be removed a minimum of 2-inches inside the finished surface of the existing structure. Wiring shall be removed and the resulting openings shall be repaired as indicated.
 6. Associated instrumentation devices shall be removed.
 7. Auxiliary utility support systems shall be removed.
 8. The area shall be thoroughly cleaned such that little or no evidence of the previous equipment installation will remain.
 9. Asphalt and concrete pavement, curbs, and gutters shall be removed as necessary to perform reconstruction. The limits of removal shall be sawcut. When the required improvements have been constructed, new asphalt and concrete pavement, curbs, and gutters shall be placed to match the original unless otherwise indicated.
 10. Footings, foundation walls, below-grade construction and concrete slabs on grade shall be demolished and removed to a depth which will not interfere with new construction, but not less than 36-inches below existing ground surface or future ground surface, whichever is lower.
 11. Below-grade areas and voids resulting from demolition of structures shall be completely filled. Fill and compaction shall be in accordance with Section 31 20 00 – Earthwork. After fill and compaction, surfaces shall be graded to meet adjacent contours and to provide flow to surface drainage structures, or as indicated.
 12. When existing pipe is removed, the Contractor shall plug the resulting open ends whether or not so indicated. Where removed piping is exposed, the remaining piping shall be blind-flanged or fitted with a removable cap or plug.

DEMOLITION

13. When existing piping is removed from existing structures, the Contractor shall fill resulting openings in the structures and repair any damage such that the finished rehabilitated structure shall appear as a new homogeneous unit with little or no indication of where the new and old materials join. The openings in water-bearing structures shall be filled with non-shrink grout to be watertight and reinforced as required or indicated. In locations where the surface of the grout will be exposed to view, the grout shall be recessed approximately 1/2-inch and the recessed area filled with cement mortar grout.
 14. Electrical reconstruction shall be conducted by the Contractor in a safe and proper manner to avoid injury from electrical shock to the Owner's and Contractor's personnel. Electrical equipment to be shut off for an extended period of time shall be tagged, locked out, and sealed with a crimped wire and lead seal and made inoperable. At no time shall electrical wiring or connections which are energized or could become energized be accessible to Contractor, Owner, or other personnel without suitable protection or warning signs.
- B. The Contractor shall perform a functional test of existing equipment that is relocated and reinstalled to ensure the equipment functions in the manner documented during the initial inspection. The Contractor shall inform the Engineer in writing a minimum of 5 Days prior to the functional testing in order for the Owner and Engineer to witness the test. If, in the opinion of the Engineer, the relocated equipment does not function in a satisfactory manner, the Contractor shall make repairs and modifications necessary to restore the equipment to its original operating condition at no additional cost to the Owner.

3.04 ABANDONMENT

- A. Existing facilities to be abandoned shall be prepared as indicated. Where existing buried piping is to be abandoned, the Contractor shall remove the abandoned pipe for a distance of 5-feet from any connecting structures. Openings at the existing structures shall be repaired. The remaining pipe shall be capped at both ends prior to backfill. Buried piping, 12-inches diameter or greater shall be completely filled with sand or flowable fill prior to closure of the piping ends.

3.05 REHABILITATION

- A. Certain areas of existing structures, piping, conduits, and the like will be affected by Work necessary to complete modifications under this Contract. The Contractor shall be responsible to rehabilitate those areas affected by its construction activities.

- B. Where new rectangular openings are to be installed in concrete or concrete masonry walls or floors, the Contractor shall score the edges of each opening (both sides of wall or floor slab) by saw-cutting clean straight lines to a minimum depth of 1-inch and then chipping out the concrete. Alternately, the sides of the opening (not the corners) may be formed by saw cutting completely through the slab or wall. Saw cuts deeper than 1-inch (or the depth of cover over existing reinforcing steel, whichever is less) shall not be allowed to extend beyond the limits of the opening. Corners shall be made square and true by a combination of core drilling and chipping or grinding. Necessary precautions shall be taken during removal of concrete to prevent debris from falling into or entering adjacent tanks in service or from damaging adjacent equipment or piping. Saw cuts allowed to extend beyond the opening shall be repaired by filling with non-shrink grout. The concrete around any exposed reinforcement steel shall be chipped back and exposed reinforcement steel cut a minimum of 2-inches from the finished face of the new opening and be painted with epoxy paint containing a corrosion inhibitor. The inside face of the new opening shall be grouted with a non-shrink grout to fill any voids and cover the exposed aggregate and shall be trowel-finished to provide a plumb and square opening.
- C. Where new piping is installed in existing structures, the Contractor shall accurately position core-drilled openings in the concrete as indicated or otherwise required. Openings shall be of sufficient size to permit a final alignment of pipelines and fittings without deflection of any part and to allow adequate space for satisfactory packing where pipe passes through the wall to provide watertightness around openings so formed. The boxes or cores shall be provided with continuous keyways to hold the filling material in place, and they shall have a slight flare to facilitate grouting and the escape of entrained air during grouting. Before placing the non-shrink grout, concrete surfaces shall be sandblasted, thoroughly cleaned of sand and any other foreign matter, and coated with epoxy bonding compound.
- D. Pipes, castings, or conduits shall be grouted in place by pouring in grout under a head of at least 4-inches. The grout shall be poured or rammed or vibrated into place to fill completely the space between the pipes, castings, or conduits, and the sides of the openings so as to obtain the same watertightness as through the wall itself. The grouted casings shall then be water cured.
- E. In locations where the surface of the grout will be exposed to view, the non-shrink grout shall be recessed approximately 1/2-inch and the recessed area filled with cement mortar grout.
- F. When new piping is to be connected to existing piping, the existing piping shall be cut square and ends properly prepared for the connection. Any damage to the lining and coating of the existing piping shall be repaired. Dielectric insulating joints shall be installed at interconnections between new and existing piping.

- G. Where existing equipment, piping, and supports, electrical panels and devices, conduits, and associated appurtenances are removed, the Contractor shall rehabilitate the affected area such that little or no evidence of the previous installation remains. Openings in concrete floors, walls, and ceilings from piping, conduit, and fastener penetrations shall be filled with non-shrink grout and finished to match the adjacent area. Concrete pads, bases associated with equipment, supports, and appurtenances shall be removed by chipping away concrete and cutting any exposed reinforced steel and anchor bolts a minimum of 2-inches below finished grade and be painted with epoxy paint. The area of concrete to be rehabilitated shall be scored by saw cutting clean, straight lines to a minimum depth of 1-1/2 inches, and concrete within the scored lines removed to a depth of 1-1/2 inches (or the depth of cover over reinforcing steel, whichever is less). The area within the scored lines shall be patched with non-shrink grout to match the adjacent grade and finish. Abandoned connections to piping and conduits shall be terminated with blind flanges, caps, and plugs suited for the material, type, and service of the pipe or conduit.
- H. Existing reinforcement to remain in place shall be protected, cleaned, and extended into new concrete. Existing reinforcement not to be retained shall be cut-off as follows:
 - 1. Where new concrete joins existing concrete at the removal line, reinforcement shall be cut-off flush with the concrete surface at the removal line.
 - 2. Where the concrete surface at the removal line is the finished surface, the reinforcement shall be cut back 2-inches below the finished concrete surface, the ends painted with epoxy paint and the remaining holes patched with a cement mortar grout.
- I. Where existing handrailing is removed, post embedment's and anchors shall be removed, and post holes shall be filled with non-shrink grout flush to the floor surface. At the point of continuation of existing handrailing, a new post with rail connections matching the existing handrailing system shall be installed. New posts in existing concrete floors shall be installed in core-drilled socket holes and the annular space between the post and hole filled with non-shrink grout.
- J. Where reconstruction activities damage the painting and coating of adjacent or nearby facilities, the damaged areas shall be surface prepared and coated in accordance with Section 09 96 00 – High Performance Coatings to match the original painting and coating with a compatible system. Surfaces of equipment items that are to be relocated shall be prepared and be coated in accordance with Section 09 96 00 – High Performance Coatings.

3.06 DISPOSAL

- A. Demolition and removal of debris shall minimize interference with roads, streets, walks, and other adjacent occupied or used facilities that shall not be closed or obstructed without permission from the Owner. Alternate routes shall be provided around closed or obstructed traffic ways.
- B. Site debris, rubbish, and other materials resulting from reconstruction operations shall be legally removed and disposed of. Structures and equipment to be demolished shall be cleaned prior to demolition and the wash water properly disposed of. No trace of these structures shall remain prior to placing of backfill in the areas from which structures were removed.

- C. Refuse, debris, and waste materials resulting from demolition and clearing operations shall not be burned.

3.07 OCCUPANCY AND POLLUTION CONTROL

- A. Water sprinkling, temporary enclosures, chutes, and other suitable methods shall be used to limit dust and dirt rising and scattering in the area. The Contractor shall comply with government regulations pertaining to environmental protection.
- B. Water shall not be used if it creates hazardous or objectionable conditions such as ice, flooding, or pollution.

3.08 CLEANING

- A. During and upon completion of Work, the Contractor shall promptly remove tools and equipment, surplus materials, rubbish, debris, and dust and shall leave areas affected by Work in a clean, approved condition.
- B. Adjacent structures shall be cleaned of dust, dirt, and debris caused by reconstruction, as requested by the Engineer or directed by governing authorities, and adjacent areas shall be returned to condition existing prior to start of Work.
- C. The Contractor shall clean and sweep the street and road daily.

END OF SECTION

SECTION 03 01 00 – MAINTENANCE OF CONCRETE

PART 1 -- GENERAL

1.01 SUMMARY

- A. Provide all materials and equipment necessary to accomplish the Work.
- B. Repair damage to concrete and concrete surfaces as directed by the client, as shown within the contract documents, or when concrete damage occurs during the removal of embedded items or from other construction activities within the scope and duration of the contract.

1.02 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

- A. The edition of the standards applicable to the Work shall be those editions referenced by the 2024 Ohio Building Code (OBC). If the standard is not referenced by the OBC, nor an OBC-referenced standard listed below, the edition of the standard applicable to the Work shall be the edition in effect on the date of signing and sealing of the contract specifications.
- B. Reference Specifications

01 33 00	Submittal Procedures
03 11 00	Concrete Forming
03 21 00	Reinforcement Bars
03 30 00	Cast-in-Place Concrete
03 15 00	Concrete Accessories
03 60 00	Grouting

- C. Reference Standards

American Concrete Institute (ACI)	
ACI 201.1R-08	Guide for Making a Condition Survey of Concrete in Service
ACI 546R-14	Concrete Repair Guide
ASTM International (ASTM)	
ASTM C109	Standard Test Method for Compressive Strength of Hydraulic Cement Mortars (Using 2-in. or [50-mm] Cube Specimens)
ASTM C595	Standard Specification for Blended Hydraulic Cement
ASTM C666	Standard Test Method for Testing Resistance of Concrete to Freezing and Thawing in Sodium Chloride Solution
ASTM C882 (modified)	Standard Test Method for Bond Strength of Epoxy-Resin Systems Used with Concrete by Slant Shear

1.03 CONTRACTOR SUBMITTALS

- A. Furnish submittals in accordance with the requirements of Section 01 33 00 – Submittal Procedures.
- B. Concrete Repair Products and Procedures

MAINTENANCE OF CONCRETE

1. Submit a comprehensive plan for each repair method indicated within this Section, the plan shall include the following:
 - a. Manufacturer's literature containing instructions and recommendations on the mixing, handling, placement, curing, and appropriate uses for each product.
 - b. Curing products and procedures for each repair method for which curing is recommended by the manufacturer.

1.04 QUALITY ASSURANCE

A. Field Tests of Cement Based Mortars and Grouts

1. The Engineer may take compression test specimens during construction from the first placement of each type of mortar or grout, and at intervals thereafter as selected by the Engineer in order to ensure continued compliance with the indicated requirements.
2. The Contractor shall assist the Engineer in obtaining specimens for testing.
3. The compression tests and fabrication of specimens for repair mortar and non-shrink grout will be performed as specified in ASTM C109.
4. A set of 5 specimens will be made for testing at 7 days, 28 days, and additional time periods as appropriate.
5. Any material, already placed, which fails to meet the indicated performance requirements is subject to removal and replacement as part of the Work.
6. The cost of laboratory tests on mortar and grout will be paid by the Owner, but the Contractor shall be responsible for the cost of any additional tests and investigation on the Work that does not meet the indicated requirements.
7. The Contractor shall supply all necessary materials for fabricating the test specimens.

B. Repair Concrete: Repair concrete shall be tested as required in Section 03 30 00 – Cast-in-Place Concrete.

C. Epoxy Grout: Epoxy grout shall be tested as required in Section 03 60 00 – Grouting.

D. Construction Tolerances: Construction tolerances shall comply with the requirements of Section 03 30 00 – Cast-in-Place Concrete, except as otherwise indicated.

PART 2 -- PRODUCTS

2.01 REPAIR MORTAR

- A. Provide repair mortar as a pre-packaged, 2-component, polymer-modified, cementitious, non-sag mortar, specifically formulated for the repair of surface defects.
- B. Provide the mortar with a penetrating corrosion inhibitor.
- C. Repair mortar shall have the following properties:

Physical Property	Value	ASTM Standard
Compressive Strength (min.)		C-109
at 7 days	6000 psi	
at 28 days	7000 psi	
Bond Strength (min.)		C-882 (modified)
at 28 days	2200 psi	
Freeze/Thaw resistance (min.)		C-666
300 cycles	98 percent	

D. Provide a minimum repair thickness of 1/4 inch, unless otherwise indicated.

E. Repair Mortar shall be SikaTop 123 Plus for vertical and overhead surfaces and SikaTop 122 Plus for horizontal surfaces, by Sika Corporation, or equal.

2.02 NON-SHRINK GROUT

A. Provide non-shrink grout conforming to the requirements of Section 03 60 00 – Grouting.

2.03 CONCRETE MATERIALS

A. Cement

1. Use ASTM C595 Type IL blended hydraulic cement unless otherwise indicated.
2. Where repairs are to be made on wall surfaces open to view and above normal water surface elevations, blend white limestone cement as needed in order to match the color of the adjacent concrete surface.

B. Structural Repair Grout

1. Where required, provide structural repair grout meeting the requirements of a Congested Section Concrete Mix design per Section 03 30 00 – Cast-in-Place Concrete.
2. As an alternate to ready mix concrete, the contractor may use Five Star Structural Concrete ES-60 by Five Star Products Inc, or equal, and extended 60% by weight with 3/8", non-reactive, washed aggregate per the manufacturer's requirements.
3. Provide a minimum repair thickness of 3 inches.

C. Miscellaneous Materials: For concrete construction materials not covered specifically in this Section, conform to the requirements of Section 03 30 00 – Cast-in-Place Concrete.

2.04 AGGREGATE

A. Obtain the written permission of the manufacturer and Engineer before using aggregate to extend repair mortar and grout products.

- B. If allowed and unless otherwise indicated, provide aggregate consisting of 3/8-inch, non-reactive, washed gravel or crushed stone as required in Section 03 30 00 – Cast-in-Place Concrete.

2.05 BONDING AGENT AND ANTI-CORROSION COATING

- A. Provide a bonding agent that is a solvent-free, moisture-tolerant, epoxy-modified, cementitious product, specifically formulated as a bonding agent and anti-corrosion coating.
- B. Bonding Agent shall be Armatec 110 EpoCem, by Sika Corporation, or equal.

2.06 EPOXY GROUT

- A. Provide an epoxy grout conforming to the requirements of Section 03 60 00 – Grouting.

2.07 EPOXY RESIN

- A. Use epoxy resin for structural crack repair.
- B. For crack injection, provide a 2-component, moisture-tolerant, low-viscosity, high-strength epoxy resin adhesive that is specially formulated for that usage.
- C. Provide a minimum bond strength (tensile adhesion strength) of 2900 psi when tested per ASTM C 882 at 14 days, moist cured.
- D. Epoxy Resin shall be Sikadur 35, Hi-Mod LV, by Sika Corporation, KEMKO 068 LoVis IR, by ChemCo Systems, Inc., or equal.

2.08 PROTECTIVE COATING

- A. Waterproofing
 - 1. Provide a 2-component, polymer-modified, cementitious waterproofing and protective slurry mortar for concrete.
 - 2. Apply the material in 2 coats, with a coverage of 40 sq ft/gal/coat.
 - 3. Waterproofing shall be Sika Top Seal 107, by Sika Corporation, or equal.

2.09 FORMWORK

- A. Where needed, provide formwork that meets the requirements of Section 03 11 00 – Concrete Forming.

2.10 REINFORCEMENT STEEL

- A. Where required, provide reinforcing steel that meets the requirements of Section 03 21 00 – Reinforcement Bars.

2.11 POLYURETHANE SEALANT

- A. Use polyurethane sealant for expansion joint repair.
- B. Provide a 2-part polyurethane, gun-grade sealant.

C. Polyurethane Sealant shall be Sikaflex – 2C, by Sika Corporation, or equal.

2.12 POLYURETHANE CHEMICAL GROUT

A. Use polyurethane chemical grout for non-structural crack repair.

B. Polyurethane Chemical Grout shall be SikaFix HH, by Sika Corporation, De Neef Flex LV PRe, by GCP Applied Technologies, De Neef Flex SLV PRe, by GCP Applied Technologies, or equal.

2.13 HYDROPHILIC WATERSTOP

A. Provide hydrophilic waterstop of the type which expands in the presence of water to form a watertight joint seal without damaging the concrete in which it is cast.

B. Provide hydrophilic waterstop that is bentonite-free and manufactured from chloroprene rubber and modified chloroprene rubber with hydrophilic properties.

C. Hydrophilic Waterstop shall be Hydrotite RSS-040 P, by Sika Corporation, KM 4mm String, by Adeka Ultra Seal, or equal.

2.14 HIGH STRENGTH EPOXY GEL

A. High-Strength Epoxy Gel for crack surface sealing shall be Denepox Rapidgel, by GCP Applied Technologies, or equal.

2.15 EPOXY BONDING ADHESIVE

A. Epoxy Bonding Adhesive shall be Sikadur 31, by Sika Corp, Tyfo S by Tyfo/Aegion, or equal.

PART 3 -- EXECUTION

3.01 GENERAL

A. Repairs

1. Repair techniques will be reviewed during the pre-construction meeting between the Contractor, Engineer, and Owner.
2. The Contractor shall be familiar with the cause of deteriorated concrete and shall choose the right equipment, repair materials and techniques to be used for each particular repair.
3. Choose repair materials to match the adjacent concrete surface in color and texture.
4. Apply repair materials in strict accordance with the manufacturer's printed instructions, including temperature and moisture requirements throughout application and curing.
5. Protect adjacent portions of the structure, including all valves, pipes, mechanical equipment, and filter media from debris generated by repair activities.

6. For portions of the structure that are not identified to be repaired, maintain in their original condition.

B. Structural Stability

1. Use caution not to weaken the structural capacity of a beam, column, wall, slab, walkway, or other concrete member during concrete removal.
2. For severely deteriorated concrete members, consult with the Engineer before removing a major portion of any structural member.
3. Shoring may be required in order to support the structure and to protect workers.

C. Provide off-site disposal of debris generated as a result of repair procedures.

D. Provide concrete construction procedures not specifically addressed in this Section in accordance with the requirements of Section 03 30 00 – Cast-in-Place Concrete.

3.02 REPAIR SEQUENCING

A. Unless otherwise indicated, perform concrete repairs in the following sequence, with no activity in an area being started until previous activities in that area have been completed, including curing, cleanup, and the like:

1. removal of equipment, miscellaneous metals, and other surface features that would interfere with the repair;
2. surface preparation hydroblasting over the entire area to be repaired;
3. embedded metal repair;
4. crack repair;
5. spalled and delaminated concrete repair;
6. scaled concrete;
7. pop-out repair, and repair of other surface damage, deterioration, or defects;
8. patching of holes in concrete;
9. new construction; and
10. application of protective coatings.

B. For areas which require combinations of spalled and delaminated concrete repair, scaled concrete, and pop-out repair, perform these repairs at the same time.

C. Limit the size of the repair area in order to permit the repairs to be performed together, without sacrificing the quality of the individual repairs.

3.03 EMBEDDED METAL REPAIR

A. Unless otherwise indicated, repair anchor bolts and other embedded metal, except rebar, that are exposed at the concrete surface and are showing signs of corrosion, as follows:

1. Cut off or otherwise remove corroded metal fastened at the surface;
 2. Trim back embedded metals to a depth of at least 2 inches beyond the surface of sound concrete;
 3. Chip away unsound concrete around the embedded metal.
 4. Apply epoxy grout to the repair area until level with the surface of the surrounding sound concrete.
- B. Unless otherwise indicated, repair embedded rebar that is exposed at the concrete surface following the procedures outlined in the appropriate concrete repair subsection, below.

3.04 CRACK REPAIR

A. Structural Cracks - Structural Cracks are defined as follows:

1. All cracks where reinforcing steel is passing across the crack, including erratic cracks, and cracks at construction joints.
2. Repair structural cracks with epoxy resin.

B. Non Structural Cracks - Non Structural Cracks are defined as follows:

1. Cracks occurring at flexible joints, contraction joints or expansion joints.
2. Repair non-structural cracks with polyurethane chemical grout.

C. Efflorescence

1. Prior to the crack repair, clean efflorescence from the cracks and the surrounding area.
2. Clean the efflorescence by light hydro-blasting or scrubbing.

D. Pressure Injection: Pressure Injection to be performed prior to leak testing and roof membrane installation.

1. General

- a. The indicated repair materials have been selected to minimize the loss of material during the injection process. The areas selected for crack repair are to be identified by the Contractor, Engineer or Construction Manager and be determined prior to leak tests and roof membrane installation. The injection of cracks may also be required as a result of the leak test.
- b. In order to avoid excessive loss of injected material at the lower exposed portions of the cracks, space the injection ports a distance no greater than the thickness of the wall being repaired.

2. Structural cracks – Open through thickness cracks are to be repaired to deliver a watertight hydraulic structure passing the specified leakage test. All 3-foot long or greater through thickness cracks, wider than 15 mils, in the walls are to be injected unless they do not accept grout. All 2-foot long or greater through thickness cracks, wider than 10 mils, in the foundation/floor slabs and roof are to be injected unless they do not accept grout. Perform structural crack repairs by pressure injection in accordance with the manufacturer's directions, and in accordance with the following basic procedure:
 - a. Remove unsound and foreign materials from the crack in a manner that does not trap debris in the crack and prevent the flow of repair materials.
 - b. Remove any contamination by flushing with water or solvent, allowing adequate time for air-drying or blow out the solvent with compressed air.
 - c. Install the injection ports in accordance with the manufacturer's directions.
 - d. Sealing
 - 1) Seal the surface in order to keep the pressure injecting materials from leaking out before it has set or gelled.
 - 2) Seal a surface by brushing an epoxy over the surface of the crack and allowing it to harden, or use high injection pressures to cut-out the cracks in a 'V' shape, fill with an epoxy, and strike off flush with the surface.
 - 3) Surface patching or sealant shall be performed where needed to provide for complete penetration of the injected polyurethane grout and to prevent wastage. Seal surface of crack with fast setting hydraulic cement or high strength epoxy gel. The floor surface along the cracks shall be cleaned and all wasted grout and surface seal material shall be completely removed from the concrete surface following completion of the repair work
 - e. Inject the repair materials, with consideration of the following items:
 - 1) Carefully select the pressure of the hydraulic pump or other device, because too much pressure can extend the cracks and cause more damage.
 - 2) For vertical cracks, start by pumping material into the entry port at the lowest elevation until the material level reaches the entry port above, then cap the lower injection port and repeat the process at successively higher ports until the crack has been completely filled.
 - 3) For horizontal cracks, start at one end of the crack and work to the other end, filling the crack until the pressure can be maintained.
 - 4) For very fine cracks, start the injection of repair material at the widest end and proceed toward the thinner end, using low-viscosity repair material.
 - f. Cleanup
 - 1) Remove the surface seal by grinding or other appropriate means.
 - 2) Coat fittings and holes at injection ports with an epoxy patching compound.

- 3) If crack repairs are part of repair for surface defects, painting with epoxy is not necessary and surface preparation may be started after crack repairs have been completed.
3. Non-structural cracks – Open through thickness cracks are to be repaired to deliver a watertight hydraulic structure passing the specified leakage test. All 3-foot long or greater through thickness cracks, wider than 15 mils, in the walls are to be injected unless they do not accept grout. All 2-foot long through thickness cracks, wider than 10 mils, in the foundation/floor slabs and roof are to be injected unless they do not accept grout. Perform non-structural crack repairs in accordance with the manufacturer's directions, and in accordance with the following basic procedure:
 - a. Remove unsound and foreign materials from the crack in a manner that does not trap debris in the crack and prevent the flow of repair materials.
 - b. Remove contamination by flushing with water or solvent, allowing adequate time for air-drying or blow out the solvent with compressed air.
 - c. Install the injection ports in accordance with the manufacturer's directions.
 - d. Moisture
 - 1) For non-structural cracks, moisture must be present for the chemical grout to react.
 - 2) Prior to injecting the repair materials, inject the crack with a small amount of water in order to completely moisten the crack.
 - e. Inject the repair materials, with consideration of the following items:
 - 1) Carefully select the pressure of the hydraulic pump or other device, because too much pressure can extend the cracks and cause more damage.
 - 2) For vertical cracks, start by pumping material into the entry port at the lowest elevation until the material level reaches the entry port above, cap the lower injection port and repeat the process at successively higher ports until the crack has been completely filled, and then, starting again at the lowest port, re-inject into all ports in order to ensure that all voids are properly sealed off.
 - 3) For horizontal cracks, start at one end of the crack and work to the other end, filling the crack until the pressure can be maintained.
 - 4) For very fine cracks, start the injection of repair material at the widest end and proceed toward the thinner end.
 - f. Cleanup
 - 1) Remove excess surface material by grinding or other appropriate means.
 - 2) Coat fittings and holes at injection ports with an epoxy patching compound.

- 3) If crack repairs are part of repair for surface defects, painting with epoxy is not necessary and surface preparation may be started after crack repairs have been completed.

3.05 SPALLED AND DELAMINATED CONCRETE REPAIR

A. Repair spalls and delaminated concrete using repair mortar.

B. Surface Preparation

1. Remove all delaminated concrete and all unsound concrete beyond the spalled or delaminated area.
2. Boundaries
 - a. Determine the boundaries of the patch by sawcuts to a depth of at least 1/4 inch up to one inch deep.
 - b. Refer to the Structural Drawings for sawcut locations.
 - c. Where the sawcut locations are not shown on the Drawings, the boundary layouts shall be designed to reduce boundary edge length.
 - d. Avoid excessive or complex edge conditions.
3. Sawcuts
 - a. Perform sawcuts perpendicular to the surface or slightly undercut.
 - b. Construct sawcuts in maximum 1/4-inch increments.
 - c. After each incremental cut, inspect the cut surface in order to ensure that the reinforcement has not been cut.
 - d. If at any depth the reinforcement becomes exposed, terminate the sawcut and notify the Engineer.
4. Chip away concrete within the repair area to a depth sufficient to expose sound concrete over the entire repair area, or to a minimum depth required by repair mortar, whichever is greater.
5. Base the selection of partial depth concrete removal equipment on the size of repair area, depth of concrete to be removed, and the location of the deteriorated concrete such as wall, slab-on-grade, underside or top of elevated slab.
6. Removal
 - a. The maximum allowable pneumatic chipping hammer shall be a 30-lb class hammer.
 - b. Hydroblast removal shall use a maximum pressure of 40,000 psi.
 - c. Sand blasting is not permitted.

- d. Hydroblast concrete removal is recommended for large area of surface defects.
- e. Remove water blasting debris daily in order to prevent it from setting up.
- f. If a chipping hammer is used, ensure that the structure and reinforcement are not damaged during the concrete removal operations.
- g. Remove protrusions, such as mortar spatter or fins, by grinding or by striking with a hammer or other tool.

7. Reinforcement

- a. Remove concrete from around reinforcement when the rebar is rusted, more than half the rebar perimeter is already exposed, the concrete bond around the rebar is broken, or if the concrete is unsound or honey-combed.
- b. Remove concrete in order to provide a clear space of minimum one inch on all sides of the reinforcement, such that the rebar can be cleaned and the repair material will completely surround the rebar.
- c. Clean exposed reinforcement by water blasting or wire brushing.
- d. After fully exposing and cleaning the reinforcement, check for steel deterioration, and if the cross-sectional area of the steel has been reduced by more than 10 percent, whether by deterioration, surface preparation, or a combination of both, provide additional reinforcement.
- e. Consult with the Engineer before adding or replacing rebar.

C. Repairing Surface Defects

- 1. Clean the concrete surface after removing unsound concrete, repairing cracks, and cleaning the reinforcement.
- 2. Ensure that the concrete surface and reinforcement are free of form-release agents, curing compounds, surface hardeners, oils, grease, chemicals, and other contaminants.
- 3. Remove dust, including new dust generated by surface preparation or scarifying.
- 4. Prior to application of the bonding agent, apply anti-corrosion coating to exposed rebar in accordance with the manufacturer's recommendations, allow the coating to dry, reapply the coating, and allow to dry again.
- 5. Prior to applying the repair mortar, apply bonding agent in accordance with the manufacturer's recommendations.
- 6. Repair Mortar
 - a. Apply repair mortar in accordance with the manufacturer's recommendations.
 - b. The thickness of each lift of repair mortar shall be in accordance with the manufacturer's recommendations, with the minimum thickness being not less than 1/4 inch.

7. Fully consolidate the repair mortar, working the material into the substrate to completely fill all pores and voids in the area to be filled.
8. Bring the repair surface into alignment with the adjacent surfaces in order to provide a uniform, even surface.
9. Float-finish the repaired surface using wood or sponge floats.
10. Match the repair surface to adjacent surfaces in texture by applying necessary coatings and surface treatments.
11. For repaired surfaces to receive a protective coating, brush-finish the surface in order to produce a roughened substrate for the coating.
12. Minimum and maximum ambient and surface temperatures shall be as recommended by repair material manufacturer.

D. Curing

1. Curing of repair mortar to receive waterproofing shall be as follows:
 - a. Keep the mortar continuously wet by the application of water for a minimum period of at least 7 consecutive days, beginning immediately after the mortar has reached final set;
 - b. Weight the curing blankets or otherwise held them in place in order to prevent being dislodged by wind or other causes, and to be substantially in contact with the concrete surface;
 - c. Ensure that edges are continuously held in place; and,
 - d. Keep the curing blankets and concrete continuously wet by the use of sprinklers or other means, both during and after normal working hours.
2. If the repair mortar is not to receive waterproofing, provide curing in accordance with the manufacturer's recommendations except that the minimum cure period shall be 7 days.
3. During cold weather, maintain the repair material temperature above 50 degrees F for at least 3 days after placement.

3.06 SCALED CONCRETE REPAIR

A. Repair scaling and pop-outs using repair mortar.

B. Surface Preparation

1. Prior to repair, prepare the surface in accordance with the repair mortar manufacturer's recommendations with the following minimum requirement.
2. Remove unsound concrete from surfaces by high-pressure water blasting, using a minimum pressure of 10,000 psi and maximum pressure of 40,000 psi.
3. Clean exposed reinforcement by water blasting or wire brushing.

C. Repairing Surface Defects

1. Clean the concrete surface after removing unsound concrete, repairing cracks, and cleaning reinforcement.
2. Ensure that the concrete surface and reinforcement are free of form-release agents, curing compounds, surface hardeners, oils, grease, food, chemicals, and other contaminants.
3. Remove dust, including new dust generated by surface preparation or scarifying.
4. Prior to application of the bonding agent, apply anti-corrosion coating to exposed rebar in accordance with the manufacturer's recommendations, allow the coating to dry, reapply the coating, and allow to dry again.
5. Prior to applying the repair mortar, apply bonding agent in accordance with the manufacturer's recommendations.
6. Apply repair mortar in accordance with the manufacturer's recommendations, using a minimum repair material thickness of 1/4 inch.
7. Fully consolidate the repair material, working the material into the substrate to completely fill all pores and voids in the area to be filled.
8. Bring the repair surface into alignment with the adjacent surfaces in order to provide a uniform, even surface.
9. Float-finish the repaired surface using wood or sponge floats.
10. Match the repair surface to adjacent surfaces in texture by applying necessary coatings and surface treatments.

D. Provide strip joint in newly placed mortar at the location of repaired cracks.

E. Curing

1. Curing of repair mortar to receive waterproofing shall be as follows:
 - a. Keep the mortar continuously wet by the application of water for a minimum period of at least 7 consecutive days, beginning immediately after the mortar has reached final set;
 - b. Weight the curing blankets or otherwise held them in place in order to prevent being dislodged by wind or other causes, and to be substantially in contact with the concrete surface;
 - c. Ensure that edges are continuously held in place; and,
 - d. Keep the curing blankets and concrete continuously wet by the use of sprinklers or other means, both during and after normal working hours.
2. If the repair mortar is not to receive waterproofing, provide curing in accordance with the manufacturer's recommendations except that the minimum cure period shall be 7 days.

3. During cold weather, maintain the repair material temperature above 50 degrees F for at least 3 days after placement.

3.07 POP-OUT REPAIR, AND REPAIR OF OTHER SURFACE DAMAGE, DETERIORATION, OR DEFECTS

- A. Repair pop-outs and other surface damage, deterioration, and defects which are 1/4 inch deep or shallower, using the procedures described under "SCALED CONCRETE REPAIR," above.
- B. Repair other pop-outs and surface damage, deterioration, and defects using the procedures described under "SPALLED AND DELAMINATED CONCRETE REPAIR," above.

3.08 PATCHING OF HOLES IN CONCRETE

A. General

1. For the purposes of this Section, holes are defined as penetrations completely through the concrete member and with interior surfaces approximately perpendicular to the surface of the member.
2. Interior surface areas which are inclined and do not meet this criteria shall be chipped as needed to meet this requirement.
3. The perimeter of holes at the surface shall form a regular shape composed of curved or straight line segments.
4. Provide the minimum depth of placement for the material used; score the concrete by sawcutting, and chip as needed to meet this requirement.
5. Roughen the interior surface of holes less than 12 inches in diameter to a minimum of 0.125-inch amplitude and roughen larger holes to a minimum of 0.25-inch amplitude.
6. At holes, coat the surface to be repaired with a bonding agent.

- B. Patching Small Holes: For holes which are less than 12 inches in their least dimension and extend completely through concrete members, fill with non-shrink grout.

C. Patching Large Holes

1. Fill holes which are larger than 12 inches in their least dimension with structural repair grout.
2. Provide large holes which are normally in contact with water or soil with hydrophilic waterstop placed in a groove.
3. Alternatively, bond the hydrophilic waterstop to the surface using an epoxy grout which completely fills all voids and irregularities beneath the waterstop material.
4. Install the waterstop in accordance with the requirements of Section 03 15 00 – Concrete Accessories.

5. Provide reinforcing steel in layers matching reinforcement location, size, spacing and cover requirements unless directed otherwise by the Engineer.

3.09 PATCHING OF LINED HOLES

A. General

1. This Work applies to those openings which have embedded material over all or a portion of their inside edge.
2. The requirements for repairing holes in concrete, as indicated above, apply as modified herein.
3. The Engineer will determine whether the embedded material is allowed to remain.

B. Where embedded material is allowed to remain, trim it back a minimum of 2 inches from the concrete surface.

C. Roughen or abrade the embedded material in order to promote good bonding to the repair material.

D. Remove substances that interfere with good bonding.

E. Completely remove embedded items that are not securely and permanently anchored into the concrete.

F. Completely remove embedded items which are larger than 12 inches in their least dimension, unless they are composed of a metal to which reinforcing steel can be welded; where reinforcement is required, weld it to the embedded metal.

G. The following requirements shall apply to concrete members which are in contact with water or soil:

1. Using epoxy grout, fill lined openings which are less than 4 inches in their least dimension;
2. Using an epoxy bonding agent, coat lined openings which are greater than 4 inches but less than 12 inches in their least dimension, prior to being filled with non-shrink grout.
3. Using an epoxy bonding agent, coat lined openings which are greater than 12 inches in their least dimension and provide a hydrophilic waterstop bonded to the interior of the opening with epoxy adhesive, prior to being filled with approved repair material.

3.10 APPLICATION OF PROTECTIVE COATINGS

A. Waterproofing

1. Apply waterproofing in accordance with the manufacturer's printed instructions.
2. Do not begin waterproofing Work until repairs and new construction in the affected area have been completed and adequately cured.

END OF SECTION

MAINTENANCE OF CONCRETE

SECTION 03 11 00 – CONCRETE FORMING

PART 1 -- GENERAL

1.01 SUMMARY

- A. The Contractor shall furnish concrete formwork, bracing, shoring, and supports for cast-in-place concrete and shall design and construct falsework, all in accordance with the Contract Documents.

1.02 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

- A. The edition of the standards applicable to the Work shall be those editions referenced by the 2024 Ohio Building Code (OBC). If the standard is not referenced by the OBC, nor an OBC-referenced standard listed below, the edition of the standard applicable to the Work shall be the edition in effect on the date of signing and sealing of the contract specifications.

B. Reference Specifications

01 33 00	Submittal Procedures
03 30 00	Cast-in-Place-Concrete

C. Reference Standards

American Concrete Institute (ACI)	
ACI 117	Standard Tolerances for Concrete Construction and Materials.
National Institute of Standards and Technology (NIST)	
Voluntary Product Standard PS 20	American Softwood Lumber Standard.
Voluntary Product Standard PS 1	Structural Plywood

1.03 CONTRACTOR SUBMITTALS

- A. Furnish submittals in accordance with Section 01 33 00 – Submittal Procedures.
- B. Manufacturer's information demonstrating compliance with requirements for the following:
1. Form ties and related accessories, including taper tie plugs, if taper ties are used.
 2. Form gaskets.
 3. Form release agent.
 4. Manufacturer's design information on formwork, form materials, and locations for use.

1.04 QUALITY ASSURANCE

- A. Tolerances: The variation from required lines or grade shall not exceed 1/4-inch in 10-feet, non-cumulative, and there shall be no offsets or visible waviness in the finished surface. Other tolerances shall be within the tolerances of ACI 117.

PART 2 -- PRODUCTS

2.01 GENERAL

- A. Except as otherwise expressly accepted by the Engineer, lumber brought on the Site for use as forms, shoring, or bracing shall be new material. Forms shall be smooth surface forms and shall be of the following materials:

Walls	Steel, fiberglass, or plywood panel
Columns	Steel, plywood, or fiberglass
Roof and floor	Plywood
All other Work	Steel panels, fiberglass, plywood or tongue and groove lumber

- B. Water-based form release agent shall be Clean Strip J1EF by Dayton Superior, or equal.

2.02 FORM AND FALSEWORK MATERIALS

- A. Materials for concrete forms, formwork, and falsework shall conform to the following requirements:
1. Lumber shall be Douglas Fir or Southern Yellow Pine, construction grade or better, in conformance with Voluntary Product Standard PS 20.
 2. Plywood for concrete formwork shall be new, waterproof, synthetic resin bonded, exterior type Douglas Fir or Southern Yellow Pine plywood manufactured especially for concrete formwork, shall conform to the requirements of Voluntary Product Standard PS 1 – Exterior Plywood for Concrete Forms, Class I, and shall be edge sealed.
 3. Form materials shall be metal, wood, plywood, or other material that will not adversely affect the concrete and will facilitate placement of concrete to the shape, form, line, and grade indicated. Metal forms shall accomplish such results. Wood forms for surfaces to be painted shall conform to the requirements of Voluntary Product Standard PS 1 – Exterior Plywood for Concrete Forms, Class I, Medium Density Overlaid (MDO) Grade.
 4. Steel leave in place forms shall not be used.
- B. Unless otherwise indicated, exterior corners in concrete members shall be provided with 3/4-inch chamfers or be tooled to 1/2-inch radius. Re-entrant corners in concrete members shall not have fillets unless otherwise indicated.
- C. Forms and falsework to support the roof and floor slabs shall be designed for the total dead load, plus a live load of 50 psf minimum. The minimum design load for combined dead and live loads shall be 100 psf.

2.03 FORM TIES

- A. Form ties shall be provided with a plastic cone or other suitable means for forming a conical hole to ensure that the form tie may be broken off back of the face of the concrete. The maximum diameter of removable cones for rod ties or other removable form tie fasteners having a circular cross-section shall not exceed 1-1/2 inches; and all such fasteners shall be such as to leave holes of regular shape for reaming. Form ties for water-retaining structures shall have integral waterstops that tightly fit the form tie so that they cannot be moved from mid-point of the tie. Form ties shall be ST-4 Hex Head Snaptide by MeadowBurke, A3 Snap-Ties by Dayton Superior, or equal.
- B. Removable taper ties may be used when approved by the Engineer. A preformed neoprene or polyurethane tapered plug sized to seat at the center of the wall shall be inserted in the hole left by the removal of the taper tie. Use HD-9 Taper-Tie by MeadowBurke, D9 Taper-Tie by Dayton Superior, or equal.

PART 3 -- EXECUTION

3.01 GENERAL

- A. Forms to confine the concrete and shape it to the required lines shall be used wherever necessary. The Contractor shall assume full responsibility for the adequate design of forms, and any forms that are unsafe or inadequate in any respect shall promptly be removed from the Work and replaced. Provide worker protection from protruding reinforcement bars in accordance with applicable safety codes. A sufficient number of forms of each kind shall be available to permit the required rate of progress to be maintained. The design and inspection of concrete forms, falsework, and shoring shall comply with applicable local, state, and Federal regulations. Plumb and string lines shall be installed before concrete placement and shall be maintained during placement. Such lines shall be used by Contractor's personnel and by the Engineer and shall be in sufficient number and properly installed. During concrete placement, the Contractor shall continually monitor plumb and string line form positions and immediately correct deficiencies.
- B. Concrete forms shall conform to the shape, lines, and dimensions of members required, and shall be substantial, free from surface defects, and sufficiently tight to prevent leakage. Forms shall be properly braced or tied together to maintain their position and shape under a load of freshly-placed concrete. If adequate foundation for shores cannot be secured, trussed supports shall be provided.
- C. Forms shall be removed unless approved otherwise by the Engineer.

3.02 FORM DESIGN

- A. Forms shall be true in every respect to the required shape and size, shall conform to the established alignment and grade, and shall be of sufficient strength and rigidity to maintain their position and shape under the loads and operations incident to placing and vibrating the concrete. Suitable and effective means shall be provided on forms for holding adjacent edges and ends of panels and sections tightly together and in accurate alignment so as to prevent the formation of ridges, fins, offsets, or similar surface defects in the finished concrete. Plywood, 5/8-inch and greater in thickness, may be fastened directly to studding if the studs are spaced close enough to prevent visible deflection marks in the concrete. The forms shall be tight so as to prevent the loss of water, cement, and fines during placing and vibrating of the concrete. Specifically, the bottom of wall forms that rest on concrete footings or slabs shall be provided with a gasket to prevent loss of fines and paste during placement and vibration of concrete. Such gasket may be a 1- to 1-1/2-inch diameter polyethylene rod held in position to the underside of the wall form. Adequate clean-out holes shall be provided at the bottom of each lift of forms. The size, number, and location of such clean-outs shall be as acceptable to the Engineer. Whenever concrete cannot be placed from the top of a wall form in a manner that meets the requirements of the Contract Documents, form windows shall be provided in the size and spacing needed to allow placement of concrete to the requirements of Section 03 30 00 - Cast-in-Place Concrete. The size, number, and location of such form windows shall be as acceptable to the Engineer.

3.03 CONSTRUCTION

- A. Vertical Surfaces: Vertical surfaces of concrete members shall be formed, except where placement of the concrete against the ground is indicated. Not less than 1-inch of concrete shall be added to the indicated thickness of a concrete member where concrete is permitted to be placed against trimmed ground in lieu of forms. Permission to do this on other concrete members will be granted only for members of comparatively limited height and where the character of the ground is such that it can be trimmed to the required lines and will stand securely without caving or sloughing until the concrete has been placed.
- B. Construction Joints: Concrete construction joints will not be permitted at locations other than those indicated, except as may be acceptable to the ENGINEER. When a second lift is placed on hardened concrete, special precautions shall be taken in the way of the number, location, and tightening of ties at the top of the old lift and bottom of the new to prevent any unsatisfactory effect whatsoever on the concrete. Pipe stubs and anchor bolts shall be set in the forms where required.
- C. Form Ties

1. Embedded Ties: Holes left by the removal of form tie cones shall be reamed with suitable toothed reamers so as to leave the surface of the holes clean and rough before being filled with mortar. Wire ties for holding forms will not be permitted. No form-tying device or part thereof, other than metal, shall be left embedded in the concrete. Ties shall not be removed in such manner as to leave a hole extending through the interior of the concrete members. The use of snap-ties that cause spalling of the concrete upon form stripping or tie removal will not be permitted. If steel panel forms are used, rubber grommets shall be provided where the ties pass through the form in order to prevent loss of cement paste. Where metal rods extending through the concrete are used to support or to strengthen forms, the rods shall remain embedded and shall terminate not less than 1-inch back from the formed face or faces of the concrete.
2. Removable Ties: Where taper ties are approved for use, the larger end of the taper tie shall be on the wet side of walls in water retaining structures. After the taper tie is removed, the hole shall be thoroughly cleaned and roughened for bond. A precast neoprene or polyurethane tapered plug shall be located at the wall centerline. The hole shall be completely filled with non-shrink grout for water bearing and below-grade walls. The hole shall be completely filled with non-shrink or regular cement grout for above-grade walls that are dry on both sides. Exposed faces of walls shall have the outer 2-inches of the exposed face filled with a cement grout that shall match the color and texture of the surrounding wall surface.

3.04 REUSE OF FORMS

- A. Forms may be reused only if in good condition and only if acceptable to the Engineer. Light sanding between uses will be required wherever necessary to obtain uniform surface texture on exposed concrete surfaces. Exposed concrete surfaces are defined as surfaces which are permanently exposed to view. In the case of forms for the inside wall surfaces of hydraulic/water retaining structures, unused tie rod holes in forms shall be covered with metal caps or shall be filled by other methods acceptable to the Engineer.

3.05 REMOVAL OF FORMS

- A. Careful procedures for the removal of forms shall be strictly followed, and this Work shall be done with care so as to avoid injury to the concrete. No heavy loading on green concrete will be permitted. In the case of roof slabs and above-ground floor slabs, forms shall remain in place until test cylinders for the roof concrete attain a minimum compressive strength of 75 percent of the 28 Day strength in Section 03 30 00. No forms shall be disturbed or removed under an individual panel or unit before the concrete in the adjacent panel or unit has attained 75 percent of the 28 Day strength and has been in place for a minimum of 7 Days. The time required to establish said strength shall be as determined by the Engineer who will make several test cylinders for this purpose from concrete used in the first group of roof panels placed. If the time so determined is more than the 7 Day minimum, then that time shall be used as the minimum length of time. Forms for vertical walls of waterholding structures shall remain in place at least 36 hours after the concrete has been placed. Forms for parts of the Work not specifically mentioned herein shall remain in place for periods of time as recommended in ACI 347 - Guide to Formwork for Concrete.

3.06 MAINTENANCE OF FORMS

- A. Forms shall be maintained in good condition, particularly as to size, shape, strength, rigidity, tightness, and smoothness of surface. Before concrete is placed, the forms shall be thoroughly cleaned. The form surfaces shall be treated with a nonstaining mineral oil or other lubricant acceptable to the Engineer. Any excess lubricant shall be satisfactorily removed before placing the concrete. Where field oiling of forms is required, the Contractor shall perform the oiling at least 2 weeks in advance of their use. Care shall be exercised to keep oil off the surfaces of steel reinforcement and other metal items to be embedded in concrete.

3.07 FALSEWORK

- A. The Contractor shall be responsible for the design, engineering, construction, maintenance, and safety of falsework, including staging, walkways, forms, ladders, and similar appurtenances, which shall equal or exceed the applicable requirements of the provisions of the OSHA Safety and Health Standards for Construction, and the requirements herein.
- B. Falsework shall be designed and constructed to provide the necessary rigidity and to support the loads. Falsework for the support of a superstructure shall be designed to support the loads that would be imposed if the entire superstructure were placed at one time.
- C. Falsework shall be placed upon a solid footing, safe against undermining, and be protected from softening. When the falsework is supported on timber piles, the maximum calculated pile loading shall not exceed 20 tons. When falsework is supported on any portion of the structure which is already constructed, the load imposed by the falsework shall be spread, distributed, and braced in such a way as to avoid any possibility of damage to the structure.

END OF SECTION

SECTION 03 15 00 – CONCRETE ACCESSORIES

PART 1 -- GENERAL

1.01 SUMMARY

- A. The Contractor shall provide joints in concrete, complete and in place, in accordance with the Contract Documents.
- B. Joints in concrete structures shall be the types defined below and will be permitted only where indicated, unless specifically accepted by the Engineer.

1.02 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

A. Reference Specifications

01 33 00	Submittal Procedures
03 30 00	Cast-in-Place-Concrete
07 92 13	Elastomeric Joint Sealants

B. Reference Standards

1. The edition of the standards applicable to the Work shall be those editions referenced by the 2024 Ohio Building Code (OBC). If the standard is not referenced by the OBC, nor an OBC-referenced standard listed below, the edition of the standard applicable to the Work shall be the edition in effect on the date of award of this contract.

American Concrete Institute (ACI)	
ACI 330.1	Specification for Unreinforced Concrete Parking Lots and Site Paving
ASTM International (ASTM)	
ASTM A775	Standard Specification for Epoxy Coated Steel Reinforcing Bars
ASTM C920	Standard Specification for Elastomeric Joint Sealants
ASTM D412	Standard Test Methods for Vulcanized Rubber and Thermoplastic Elastomers – Tension
ASTM D624	Standard Test Method for Tear Strength of Conventional Vulcanized Rubber and Thermoplastic Elastomers
ASTM D638	Standard Test Method for Tensile Properties of Plastics
ASTM D746	Standard Test Method for Brittleness Temperature of Plastics and Elastomers by Impact
ASTM D747	Standard Test Method for Apparent Bending Modulus of Plastics by Means of a Cantilever Beam
ASTM D1056	Standard Specification for Flexible Cellular Materials – Sponge or Expanded Rubber
ASTM D1752	Standard Specification for Preformed Sponge Rubber, Cork, and Recycled PVC Expansion Joint Fillers for Concrete Paving and Structural Construction

ASTM D2000	Standard Classification System for Rubber Products in Automotive Applications
ASTM D2240	Standard Test Method for Rubber Property – Durometer Hardness
ASTM D2241	Standard Specification for PolyVinylchloride (PVC) Pressure-Rated Pipe (SDR Series)
National Bureau of Standards	
Federal Specification TT-S-0227E	Sealing Compound: Elastomeric Type, Multi-Component (For Caulking, Sealing and Glazing in Buildings and Other Structures)
U.S. Army Corps of Engineers	
Specification CRD-C572	Specification for PolyVinylchloride Waterstops

1.03 TYPES OF JOINTS

A. Construction Joints

1. When fresh concrete is placed against a hardened concrete surface, the joint between the pours shall be defined as a construction joint.
2. Construction joints in water-bearing members shall be provided with a waterstop.
3. Construction joints shall have sealant grooves of the shape indicated, except where indicated otherwise.

B. Contraction Joints

1. Contraction joints are similar to construction joints except that the fresh concrete shall not bond to the hardened surface of the earlier pour.
2. The slab reinforcement shall be stopped 4 inches from the joint; which is provided with a sleeve-type dowel, in order to allow shrinkage of the concrete of the later pour.
3. Waterstop and/or sealant groove shall be provided where indicated.
4. At full contraction joints, all reinforcement is terminated clear of the joint. At partial contraction joints, a portion of the reinforcement is terminated clear of the joint, with the remainder being continuous through the joint.

C. Expansion Joints

1. In order to allow the concrete to expand freely, a space shall be provided between the 2 pours, and the joint shall be formed as indicated.
2. The space shall be obtained by placing a joint filler material against the earlier pour to act as a form for the later pour.
3. Unless otherwise indicated, expansion joints in water bearing members shall be provided with a center-bulb type waterstop.
4. Provide premolded expansion joint filler material with the edge at the indicated distance below or back from the finished concrete surface.

5. Provide a slightly tapered, dressed and oiled wooden strip secured to or placed at the edge of the expansion joint during concrete placement and remove the strip later to form a space for the sealing material.
6. The space so formed shall be filled with a joint sealant material as indicated below. In order to keep the 2 wall or slab elements in line, the joint shall also be provided with a sleeve-type dowel as indicated.

D. Control Joints

1. The function of the control joint is to provide a weaker plane in the concrete where shrinkage cracks would likely occur.
2. Formed Groove
 - a. A groove, of the shape and dimensions indicated, shall be formed or saw-cut in the concrete and the groove shall then be filled with a joint sealant material.
 - b. The formed groove shall be placed in the first of the two sections cast at the control joint, in order to assure that the sealant bonds to the second section across the joint and not to the cement paste from the first pour.

1.04 CONTRACTOR SUBMITTALS

- A. Furnish submittals in accordance with the requirements of Section 01 33 00 – Submittal Procedures.
- B. Shop Drawings
 1. Furnish placement drawings showing the location and types of joints for each structure.
 2. Test Reports
 - a. Furnish certified test reports from the sealant manufacturer on the actual batch of material supplied, demonstrating compliance with the indicated requirements.
 - b. Furnish the test reports before using the sealant on the Project.
 3. Welding Certification
 - a. Furnish copies of the waterstop welding certification by manufacturer or authorized agent of the manufacturer.
 - b. Every person who is to be involved with waterstop installation shall be required to have individual certification on file with the Engineer, stating that the named individual is certified and trained to install waterstop in accordance with the manufacturer's recommendations and specifications.
 4. Joint Sealant Installation Certification
 - a. Furnish copies of the joint sealant installation certification by manufacturer or authorized agent of the manufacturer.

- b. Every person who is to be involved with joint sealant installation shall be required to have individual certification on file with the Engineer, stating that the named individual is certified and trained to install joint sealant in accordance with the manufacturer's recommendations and specifications.
- 5. Furnish manufacturer's information demonstrating compliance of the following with the indicated requirements:
 - a. bearing pad
 - b. neoprene sponge
 - c. preformed joint filler
 - d. backing rod
 - e. waterstop
 - f. slip dowels
 - g. PVC tubing

C. Samples

- 1. Prior to production of the material required under this Section, submit qualification samples of waterstops which accurately represent the material being provided.
- 2. Such samples shall be extruded or molded sections of each size or shape to be installed.
- 3. The balance of the material to be used shall not be produced until after the Engineer has reviewed the qualification samples.

D. Certificates

- 1. Furnish written certification from the manufacturer, as an integral part of the shipping form, that the material shipped to the Site meets or exceeds the indicated physical property requirements.
- 2. Supplier certificates will not be accepted.

1.05 QUALITY ASSURANCE

A. Waterstop Inspection

- 1. Field joints in waterstops shall be subject to inspection. No such Work shall be scheduled or started without having made prior arrangements with the Engineer for the required inspections.
- 2. Provide not less than 24 hours' notice for the scheduling of such inspections.
- 3. Field joints in PVC waterstops shall be subject to inspection for misalignment, bubbles, inadequate bond, porosity, cracks, offsets, and other defects that would reduce the potential resistance of the material to water pressure at any point.

4. Defective field joints shall be replaced with material that passes inspection, and faulty material shall be removed from the Site and destroyed.
- B. The following waterstop defects represent a partial list of defects which shall be grounds for rejection:
1. Offsets at joints greater than 1/16 inch or 15 percent of material thickness at any point, whichever is less
 2. Exterior cracking at the joint due to incomplete bond, which is deeper than 1/16 inch or 15 percent of material thickness at any point, whichever is less
 3. Any combination of offset or exterior cracking that will result in a net reduction in the cross-section of the waterstop in excess of 1/16 inch or 15 percent of material thickness at any point, whichever is less
 4. Misalignment of the joint which results in misalignment of the waterstop in excess of 1/2 inch in 10 feet
 5. Porosity in the welded joint as evidenced by visual inspection
 6. Bubbles or inadequate bonding which can be detected with a penknife test. (If, while prodding the entire joint with the point of a penknife, the knife breaks through the outer portion of the weld into a bubble, the joint shall be considered defective.)
 7. Visible signs of separation when the cooled splice is bent by hand at any sharp angle
 8. Evidence of burned material
- C. Waterstop Samples
1. Prior to use of the waterstop material in the field, a sample of a prefabricated (shop made fitting) mitered cross and a tee constructed of each size or shape of material to be used shall be submitted.
 2. Samples shall be prefabricated (shop made fitting) so that the material and workmanship represent the fittings to be provided.
 3. In addition, field samples of prefabricated fittings (crosses, tees, and the like) will be selected at random by the Engineer for testing by a laboratory at the Owner's expense.
 4. When tested, the tensile strength across the joints shall be at least 1120 psi for PVC waterstops.
- D. Construction Joint Sealant
1. The Contractor shall prepare adhesion and cohesion test specimens at intervals of 5 Days while sealants are being installed.
 2. The sealant material shall show no signs of adhesive or cohesive failure when tested in accordance with the following procedure in laboratory and field tests:

- a. Sealant specimen shall be prepared between 2 concrete blocks (1-inch by 2-inch by 3-inch).
- b. Spacing between the blocks shall be one inch.
- c. Coated spacers (2-inch by 1-1/2-inch by 1/2-inch) shall be used to set and hold sealant cross-sections of 1/2-inch by 2-inch with a width of one inch.
- d. The sealant shall be cast and cured in accordance with the manufacturer's recommendations, except that the curing period shall be not less than 24 hours.
- e. Following the curing period, the gap between the blocks shall be widened to 1-1/2 inches, and spacers shall be used to maintain this gap for 24 hours prior to inspection for failure.

1.06 SPECIAL CORRECTION OF DEFECTS REQUIREMENT

- A. The Contractor shall furnish a 5-year written warranty of the entire sealant installation against faulty and/or incompatible materials and workmanship, together with a statement that the Contractor agrees to repair or replace, to the satisfaction of the Owner, any defective areas which become evident within the 5-year period.

PART 2 -- PRODUCTS

2.01 WATERSTOPS

A. PVC Waterstops

1. PVC waterstops shall be Earthshield, by JP Specialties, Greenstreak, by Sika, Vinylex PVC Waterstop, by Vinylex, or equal.
2. Waterstops shall be extruded from an elastomeric polyvinyl chloride compound containing the plasticizers, resins, stabilizers, and other materials necessary to meet the indicated requirements of this Section.
3. No reclaimed or scrap material shall be used.
4. The Contractor shall obtain from the waterstop manufacturer and shall furnish to the Engineer for review, current test reports and a written certification of the manufacturer that the material to be shipped to the Site meets the physical requirements as outlined in CRD-C572, and those indicated.
5. Flatstrip and Center-Bulb Waterstops
 - a. Flatstrip and center-bulb waterstops shall be manufactured such that at no place shall the thickness of waterstops, including the center bulb type, be less than 3/8 inch.
 - b. The waterstop shall be provided with hog rings or eyelets installed at 12 inches on centers along the waterstop.
 - c. Shapes shall be as indicated, or as acceptable to the Engineer.
6. Multi-Rib Waterstops

- a. Multi-rib waterstops shall be as indicated or as acceptable to the Engineer.
 - b. Prefabricated joint fittings shall be used at intersections of the ribbed-type waterstops.
7. When tested in accordance with the indicated test standards, the waterstop material shall meet or exceed the following requirements:

Physical Property, Sheet Material	Value	ASTM Std
Tensile Strength-min, psi	2000	D 638, Type IV
Ultimate Elongation-min, percent	300	D 638, Type IV
Low Temp Brittleness, max degrees F	-35	D 746
Stiffness in Flexure, min, psi	600	D 747
Change in Durometer, Shore A	Plus or minus 5	D 2240
Tear Strength, min, lb/inch	300	D 624
Accelerated Extraction (CRD-C572)		
Tensile Strength-min, psi	1500	D 638, Type IV
Ultimate Elongation, min, percent	300	D 638, Type IV
Effect of Alkalies (CRD-C572)		
Change in Weight, percent	plus 0.25/minus 0.10	-----

B. Preformed Hydrophilic Waterstop

1. Hydrophilic waterstops shall be HF302-Hydro-Flex Waterstop by Henry Co., Earthshield Type NB 190, by JP Specialties, or equal.
2. The cross-sectional area of the waterstop shall not be less than 0.5 square inch.
3. Hydrophilic waterstop shall be the type that expands in the presence of water to form a watertight joint seal without damaging the concrete in which it is cast.
4. The waterstop shall be manufactured from butyl or modified chloroprene rubber with hydrophilic properties.
5. The waterstop shall have a delay coating to inhibit initial expansion due to moisture present in fresh concrete.
6. The minimum expansion ratio shall be not less than 2-to-1 volumetric change in distilled water at 70 degrees F (21 degrees C).
7. The bonding agent for hydrophilic waterstop shall be the manufacturer's recommended adhesive for wet, rough concrete.

C. When types of waterstops not listed above are indicated, they shall be subjected to the same requirements as those listed in this Section.

2.02 JOINT SEALANT FOR WATER-BEARING JOINTS

- A. The joint sealant shall be a polyurethane polymer designed for bonding to concrete which is continuously submerged in water.

- B. No material will be accepted which has an unsatisfactory history as to bond or durability when used in the joints of water-retaining structures.
- C. Joint sealant material shall meet the following requirements (73 degrees F and 5 percent R.H.):

Work Life, minutes	45 - 180
Time to Reach 20 Shore A Hardness (at 77 degrees F, 200 gram quantity), max	24 hours
Ultimate Hardness (ASTM D 2240, Shore A)	20 - 45
Tensile Strength (ASTM D 412), min	170 psi
Ultimate Elongation (ASTM D 412), minimum	400 percent
Tear Resistance (Die C, ASTM D 624), pounds per inch of thickness, min	75
Color	Light Gray

- D. Polyurethane sealants for waterstop joints in concrete shall conform to the following requirements:

1. Sealant shall be a multi-component polyurethane elastomeric sealant with the physical properties of the cured sealant conforming to or exceeding the requirements of ASTM C 920 or Federal Specification TT-S-0227 E(3) , for multi-component material, as applicable.
2. For vertical joints and overhead horizontal joints, only "non-sag" compounds shall be used, conforming to the requirements of ASTM C 920, Class 25, Grade NS, or Federal Specification TT-S-0227 E(3), Type II, Class A.
3. For plane horizontal joints, use the self-leveling compounds meeting the requirements of ASTM C 920 Class 25, Grade P, or Federal Specification TT-S-0227 E(3), Type I.
4. For joints subject to either pedestrian or vehicular traffic, a compound providing non-tracking characteristics and having a Shore A hardness range of 35 to 45 shall be used.
5. Primer materials, if recommended by the sealant manufacturer, shall conform to the printed recommendations of the manufacturer.

E. Sealant Manufacturers

1. Sealants shall be PSI-270 by Polymeric Systems Inc., Sikaflex 2C SL/NS, by Sika Corporation, Pelseal (with Viton) 2112/2012 by Pelseal Technologies, LLC, or equal.

- F. Sealants for non-waterstop joints in concrete shall be in conformance with the requirements of Section 07 92 13 – Elastomeric Joint Sealants.

2.03 JOINT MATERIALS

A. Bearing Pad

1. The bearing pad shall be neoprene conforming to ASTM D2000 BC 420, 40 durometer hardness, unless otherwise indicated.

B. Neoprene Sponge

1. The sponge shall be neoprene, closed-cell, expanded, conforming to ASTM D1056 Type 2C5-E1.

C. Joint Filler

1. Joint filler for expansion joints in waterholding structures shall be neoprene conforming to ASTM D 1056, Type 2C5-E1.
2. Joint filler material in other locations shall be of the preformed non-extruding type, constructed of cellular neoprene sponge rubber or polyurethane of firm texture.
3. Bituminous fiber type will not be accepted.
4. Non-extruding and resilient-type preformed expansion joint fillers shall conform to the requirements and tests set forth in ASTM D 1752 for Type I, except as otherwise indicated.

2.04 BACKING ROD

- A. The backing rod shall be an extruded closed-cell, polyethylene foam rod.
- B. The rod material shall be compatible with the joint sealant material, and shall have a tensile strength of not less than 40 psi and a compression deflection of approximately 25 percent at 8 psi.
- C. The rod shall be 1/8 inch larger in diameter than the joint width except that a one-inch diameter rod shall be used for a 3/4-inch wide joint.

2.05 BOND BREAKER TAPE

- A. Bond breaker tape shall be an adhesive-backed glazed butyl or polyethylene tape that will satisfactorily adhere to the premolded joint filler or concrete surface, as required. The tape shall be the same width as the bottom of the groove.

2.06 SLIP DOWELS

- A. Slip dowels in joints shall be smooth epoxy-coated bars conforming to ASTM A 775.

2.07 PVC TUBING

- A. PVC tubing in joints shall be SDR 13.5, conforming to ASTM D 2241.

PART 3 -- EXECUTION

3.01 GENERAL

- A. Waterstops shall be embedded in the concrete across joints as indicated.
- B. Waterstops shall be fully continuous for the extent of the joint.
- C. Splices necessary to provide such continuity shall conform to the printed instructions of the waterstop manufacturer.

- D. The Contractor shall take suitable precautions and provide means to support and protect the waterstops during the progress of the Work, and shall repair or replace any waterstops damaged during progress of the Work at no additional cost to the Owner.
- E. Waterstops shall be stored so as to permit free circulation of air around the waterstop material.
- F. When any waterstop is installed in the concrete on one side of a joint while the other portion of the waterstop remains exposed to the atmosphere for more than 2 Days, suitable precautions shall be taken to shade and protect the exposed waterstop from direct rays of the sun during the entire exposure time until the exposed portion of waterstop is embedded in concrete.

3.02 SPLICES IN PVC WATERSTOPS

- A. Splices in PVC waterstops shall be performed by heat sealing the adjacent waterstop sections in accordance with the manufacturer's printed recommendations.
- B. It is essential that:
 - 1. The material shall not be damaged by heat sealing.
 - 2. The splices shall have a tensile strength of not less than 80 percent of the unspliced material.
 - 3. The continuity of the waterstop ribs and of its tubular center axis shall be maintained.
 - 4. No welding of edges be performed.
- C. Butt joints of the ends of 2 identical waterstop sections may be made while the material is in the forms.
- D. Other Joints
 - 1. Joints with waterstops involving more than 2 ends to be jointed together, and joints that involve an angle cut, alignment change, or the joining of 2 dissimilar waterstop sections, shall be prefabricated prior to placement in the forms, allowing not less than 24-inch long strips of waterstop material beyond the joint.
 - 2. Upon inspection and approval, such prefabricated waterstop joint assemblies shall be installed in the forms and the ends of the 24-inch strips shall be butt-welded to the straight run portions of waterstop in place in the forms.
- E. Where a centerbulb waterstop intersects and is jointed with a non-centerbulb waterstop, care shall be taken to seal the end of the centerbulb, using additional PVC material if needed.

3.03 JOINT CONSTRUCTION

- A. Setting Waterstops
 - 1. In order to eliminate faulty installation that may result in joint leakage, particular care shall be taken as to the correct positioning of the waterstops during installation.

2. Adequate provisions shall be made to support and anchor the waterstops during the progress of the Work and to ensure proper embedment in the concrete.
3. The symmetrical halves of the waterstops shall be equally divided between the concrete pours at the joints.
4. The center axis of the waterstops shall be coincident with the joint openings.
5. Thoroughly work the concrete in the vicinity of joints for maximum density and imperviousness.

B. Waterstop Placement

1. In placing waterstops in the forms, means shall be provided to prevent them from being folded over by the concrete as it is placed.
2. Waterstops shall be held in place with light wire ties on 12-inch centers, which shall be passed through hog rings or eyelets at the edge of the waterstop and tied to the curtain of reinforcing steel.
3. Horizontal waterstops, with their flat face in a vertical plane, shall be held in place with continuous supports to which the top edge of the waterstop shall be tacked.
4. In placing concrete around horizontal waterstops with their flat face in a horizontal plane, the concrete shall be worked under the waterstops by hand in order to avoid the formation of air and rock pockets.

C. In placing centerbulb waterstops in expansion joints, the centerbulb shall be centered on the joint filler material.

D. Waterstop in vertical wall joints shall terminate 6 inches from the top of the wall, where such waterstop does not connect with any other waterstop and is not to be connected to a future concrete placement.

E. Joint Location

1. Construction joints and other types of joints shall be provided where indicated.
2. If not indicated, construction joints shall be provided at a 25-foot maximum spacing.
3. The location of joints, regardless of type, shall be submitted for acceptance by the Engineer.

F. Joint Preparation

1. Special Care shall be used in preparing concrete surfaces at joints where bonding between 2 sections of concrete is required.
2. Unless otherwise indicated, such bonding shall be required at every horizontal joint in walls, including at tops and bottoms of walls.
3. Surfaces shall be prepared in accordance with Section 03 30 00 – Cast-in-Place Concrete.

G. Construction Joint Sealant

1. Construction joints in water-bearing floor slabs and elsewhere, as indicated, shall be provided with tapered grooves which shall be filled with a construction joint sealant.
 2. The material used to form the tapered grooves shall be left in the grooves until just before the grooves are cleaned and filled with joint sealant.
 3. After removing the forms from the grooves, laitance and fins shall be removed, and the grooves shall be sand blasted.
 4. The grooves shall be allowed to thoroughly dry, after which they shall be blown out.
 5. Install bond breaker tape at the bottom of the groove.
 6. Prime the bonding surfaces and fill the grooves with the construction joint sealant.
 7. The primer shall be furnished by the sealant manufacturer, and no sealant shall be used without a primer.
 8. Care shall be used to completely fill the sealant grooves.
 9. Areas designated to receive a sealant fillet shall be thoroughly cleaned as outlined for the tapered grooves prior to application of the sealant.
- H. The primer and sealant shall be placed strictly in accordance with the printed recommendations of the manufacturer, taking special care to properly mix the sealant prior to application.
- I. The sides of the sealant groove shall not be coated with bond breaker, curing compound, or any other substance which would interfere with proper bonding of the sealant.
- J. The sealant shall achieve final cure at least 7 Days before the structure is filled with water.
- K. The sealant shall be installed by a competent worker certified by the sealant manufacturer.

L. Mixing

1. Catalyst-cured, 2-part materials shall be thoroughly and uniformly mixed, and special care shall be taken to properly mix the sealer before its application.

M. Failure to Cure

1. Any joint sealant that fails to fully and properly cure after the manufacturer's recommended curing time for the conditions of the Work shall be completely removed, and the groove shall be thoroughly sandblasted to remove traces of the uncured or partially cured sealant and primer.
2. The groove shall be re-sealed with the indicated joint sealant.

3. Costs of such removal, joint treatment, re-sealing, and appurtenant Work shall be the Contractor's responsibility as part of the Work.

N. Hydrophilic Waterstop

1. Where a hydrophilic waterstop is indicated, it shall be installed in accordance with the manufacturer's instructions and recommendations except as may be modified in this Section.
2. When requested by the Engineer, the Contractor shall arrange for the manufacturer to furnish technical assistance in the field.
3. Hydrophilic waterstop shall only be used where complete confinement by concrete is provided.
4. Hydrophilic waterstop shall not be used in expansion or contraction joints nor in the first 6 inches of a non-intersecting joint.
5. Location
 - a. The hydrophilic waterstop shall be located as near as possible to the center of the joint, and it shall be continuous around the entire joint.
 - b. The minimum distance from the edge of the waterstop to the face of the member shall be 5 inches.
6. Placement
 - a. Where the thickness of the concrete member to be placed on the hydrophilic waterstop is less than 12 inches, the waterstop shall be placed in grooves formed or ground into the concrete.
 - b. The groove shall be at least 3/4 inch deep and 1-1/4 inches wide.
 - c. When placed in the groove, the minimum distance from the edge of the waterstop to the face of the member shall be 2-1/2 inches.
7. Where a hydrophilic waterstop is used in combination with PVC waterstop, the hydrophilic waterstop shall overlap the PVC waterstop for a minimum of 6 inches and shall be adhered to PVC waterstop by a single component water-swelling sealant as recommended by the manufacturer.
8. Follow manufacturer's recommendations for application in cold weather (less than 45 degrees F).
9. Preparation
 - a. The concrete surface under the hydrophilic waterstop shall be smooth and uniform, and the concrete shall be ground smooth if needed.
 - b. Alternatively, the hydrophilic waterstop shall be bonded to the surface using an epoxy grout that completely fills voids and irregularities beneath the waterstop material.

- c. Prior to installation, the concrete surface shall be wire brushed to remove any laitance or other materials that may interfere with the bonding of epoxy.

10. Securing

- a. The hydrophilic waterstop shall be secured in place with concrete nails and washers at 12-inch maximum spacing.
- b. The above requirement shall be in addition to the adhesive recommended by the manufacturer.

END OF SECTION

SECTION 03 21 00 – REINFORCEMENT BARS

PART 1 -- GENERAL

1.01 SUMMARY

- A. Provide reinforcement steel and appurtenant Work, complete and in place, in accordance with the Contract Documents.

1.02 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

A. Reference Specifications

01 33 00	Submittal Procedures
03 60 00	Grouting

B. Reference Standards

1. The edition of the standards applicable to the Work shall be those editions referenced by the 2024 Ohio Building Code (OBC). If the standard is not referenced by the OBC, nor an OBC-referenced standard listed below, the edition of the standard applicable to the Work shall be the edition in effect on the date of signing and sealing of the contract specifications.

American Concrete Institute (ACI)	
ACI 117	Specification for Tolerances for Concrete Construction and Materials
ACI 318	Building Code Requirements for Structural Concrete
ASTM International (ASTM)	
ASTM A615	Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement
ASTM A 706	Low Alloy Steel Deformed and Plain Bars for Concrete Reinforcement
ASTM A 775	Epoxy - Coated Reinforcing Steel Bars
ASTM A 1064	Standard Specification for Carbon-Steel Wire and Welded Wire Reinforcement, Plain and Deformed, for Concrete
American Welding Society (AWS)	
AWS D1.4	Structural Welding Code – Reinforcing Steel
Concrete Reinforcing Steel Institute (CRSI)	
CRSI	Manual of Standard Practice

1.03 CONTRACTOR SUBMITTALS

- A. Furnish submittals in accordance with the requirements of Section 01 33 00 – Submittal Procedures.
- B. Shop Drawings
1. Furnish shop bending diagrams, placing lists, and drawings of reinforcement steel prior to fabrication.

REINFORCEMENT BARS

2. Diagrams

- a. The shop bending diagrams shall show the actual lengths of bars to the nearest inch, measured to the intersection of the extensions (tangents for bars of circular cross section) of the outside surface.
- b. Include bar placement diagrams that clearly indicate the dimensions of each bar splice.

3. Reinforcement

- a. Details of the concrete reinforcement steel and concrete inserts shall be submitted at the earliest possible date after receipt by the Contractor of the Notice to Proceed.
- b. Said details of reinforcement steel for fabrication and erection shall conform to the CRSI Manual of Standard Practice, and the indicated requirements.
- c. Mill certificates, including reinforcing steel yield and tensile strength test data.

4. Mechanical Couplers

- a. Where mechanical couplers are required or permitted to be used to splice reinforcement steel, submit the following items:
 - 1) manufacturer's literature containing instructions and recommendations for installation for each type of coupler used;
 - 2) certified test reports that verify the load capacity of each type and size of coupler used; and
 - 3) Shop Drawings that show the location of each coupler with details of how they are to be installed in the formwork.

5. Welding

- a. If reinforcement steel is to be spliced by welding at any location, submit mill test reports containing the information necessary for determination of the carbon equivalent per AWS D1.4.
- b. Submit a written welding procedure for each type of weld for each size of bar which is to be spliced by welding; merely a statement that AWS procedures will be followed is not acceptable.
- c. If reinforcement steel is spliced by welding at any location, submit certifications of procedure qualifications for each welding procedure and certification of welder qualifications, for each welding procedure and for each welder performing on the Work.

1.04 QUALITY ASSURANCE

A. Materials Testing

1. If requested by the Engineer, furnish samples from each heat of reinforcement steel in a quantity adequate for testing.

REINFORCEMENT BARS

2. Costs of initial tests will be paid by the Owner.
3. Costs of additional tests if material fails initial tests shall be the Contractor's responsibility.

B. Welding

1. Welder qualifications and procedure qualifications shall be as indicated in AWS D1.4.
2. If requested by the Engineer, furnish samples of each type of welded splice in a quantity and of dimensions adequate for testing.
3. At the discretion of the Engineer, radiographic testing of direct butt-welded splices will be performed.
4. Provide assistance necessary to facilitate testing.
5. Repair welds that fail to meet AWS D1.4.
6. The costs of testing will be paid by the Owner, but the costs of tests that show failure to meet requirements shall be the Contractor's responsibility.

PART 2 -- PRODUCTS

2.01 REINFORCEMENT STEEL

- A.** Reinforcement steel for cast-in-place reinforced concrete construction shall conform to the following requirements:

1. Deformed Bar Reinforcement

- a. Deformed bar reinforcement shall conform to ASTM A615 for Grade 60 reinforcement, unless otherwise indicated.

b. Welded Reinforcement

- 1) Deformed bar reinforcement that is welded shall conform to ASTM A706 for Grade 60 reinforcement, unless otherwise indicated.
- 2) The carbon equivalent in reinforcing that is welded shall not exceed 0.55 percent.

2. Welded Wire Reinforcement

- a. Welded wire reinforcement shall conform to ASTM A1064 and the indicated Details.
- b. Welded wire reinforcement with longitudinal wire of W4 size wire and smaller shall be in flat sheets or in rolls with a core diameter of not less than 10-inches.
- c. Welded wire reinforcement with longitudinal wires larger than W4 size shall be in flat sheets only.

B. Accessories

REINFORCEMENT BARS

1. Accessories shall include necessary chairs, slab bolsters, concrete blocks, tie wires, dips, supports, spacers, and other devices to position reinforcement during concrete placement.
2. Bar Supports
 - a. Bar supports shall meet the requirements of the CRSI Manual of Standard Practice, including special requirements for supporting epoxy-coated reinforcing bars.
 - b. Wire bar supports shall be CRSI Class 1 for maximum protection with a 1/8-inch minimum thickness of plastic coating that extends at least 1/2 inch from the concrete surface.
 - c. Plastic shall be gray in color.
3. Concrete Blocks
 - a. Concrete blocks (dobies) used to support and position reinforcement steel shall have the same or higher compressive strength as required for the concrete in which they are located.
 - b. Wire ties shall be embedded in concrete block bar supports.
- C. Epoxy coating for reinforcing and accessories, where indicated, shall conform to ASTM A775.

2.02 MECHANICAL COUPLERS

- A. Mechanical couplers shall be provided where indicated and where approved by the Engineer.
- B. The couplers shall develop a tensile strength and compressive strength that exceeds 125 percent of the specified yield strength of the reinforcement bars being spliced at each splice and shall develop the specified tensile strength of the reinforcement bars being spliced at each splice.
- C. Multi-Component Couplers
 1. Where the type of coupler used is composed of more than one component, components required for a complete splice shall be provided.
 2. This shall apply to mechanical splices, including those splices intended for future connections.
- D. Connection
 1. The reinforcement steel and coupler used shall be compatible for obtaining the required strength of the connection.
 2. Straight threaded type couplers shall require the use of the next larger size reinforcing bar or shall be used with reinforcing bars with specially forged ends which provide upset threads which do not decrease the basic cross section of the bar.

- E. Couplers shall be Lenton Form Saver by Erico Products, Dowel Bar Splicer System by Dayton/Richmond, or equal.

2.03 WELDED SPLICES

- A. Welded splices shall be provided where indicated and where approved by the Engineer.
- B. Welded splices of reinforcement steel shall develop a tensile strength that exceeds 125 percent of the specified yield strength of the reinforcement bars that are connected.
- C. Materials as required to conform the welded splices to AWS D1.4 shall be provided.

2.04 EPOXY GROUT

- A. Epoxy for grouting reinforcing bars shall be specifically formulated for such application, for the moisture condition, application temperature, and orientation of the hole to be filled.
- B. Epoxy grout shall be in conformance with the requirements of Section 03 60 00 - Grouting.

PART 3 -- EXECUTION

3.01 GENERAL

- A. Reinforcement steel, welded wire fabric, couplers, and other appurtenances shall be fabricated, and placed in accordance with the Building Code and the indicated supplementary requirements.

3.02 FABRICATION

A. General

1. Reinforcement steel shall be accurately formed to the dimensions and shapes indicated, and the fabricating details shall be prepared in accordance with ACI 318 and the CRSI Manual of Standard Practice, except as modified by the Drawings.
2. Bars shall be bent cold.
3. Bars shall be bent in accordance with the requirements of ACI 318.
4. Fabricate reinforcement bars for structures in accordance with accepted bending diagrams, placing lists, and placing drawings.

B. Fabricating Tolerances

1. Bars used for concrete reinforcement shall conform to the following fabricating tolerances:
 - a. Sheared Length: plus and minus one inch
 - b. Depth of Truss Bars: plus zero, minus 1/2 inch

c. Stirrups and Ties: plus and minus 1/2 inch

d. Other Bends: plus and minus one inch

3.03 PLACEMENT

- A. Reinforcement steel shall be accurately positioned as indicated and shall be supported and wired together to prevent displacement using annealed iron wire ties or suitable clips at intersections.
- B. Reinforcement steel shall be supported by concrete, plastic or metal support spacers, or metal hangers that are sufficiently strong and rigid to prevent any displacement of the reinforcement steel.
- C. Where concrete is to be placed on the ground, supporting concrete blocks (or dobies) shall be used in sufficient numbers to support the bars without settlement, but in no case shall such support be continuous.
- D. Concrete blocks used to support reinforcement steel shall be tied to the steel with wire ties that are embedded in the blocks.
- E. For concrete over formwork, provide concrete, metal, plastic, or other acceptable bar chairs and spacers.
- F. Limitations on the use of bar support materials shall be as follows.
 - 1. Concrete Dobies
 - a. permitted at any location except where architectural finish is required
 - b. required for slabs on grade and surfaces in contact with or above ozonated process water
 - 2. Wire bar supports will be permitted only at slabs over dry areas, interior dry wall surfaces, and exterior wall surfaces.
 - 3. Plastic bar supports will be permitted at every location except on-grade.
- G. Tie wires shall be bent away from the forms in order to provide the required concrete coverage.
- H. Bars additional to those indicated that may be found necessary or desirable by the Contractor for the purpose of securing reinforcement in position shall be provided by the Contractor at no additional expense to the Owner.
- I. Except where in conflict with the Building Code, unless otherwise indicated, reinforcement placing tolerances shall be within the limits indicated in ACI 318.
- J. Moving Bars
 - 1. Bars may be moved as necessary to avoid interference with other reinforcement steel, conduits, or embedded items.

2. If bars are moved more than one bar diameter or enough to exceed the above tolerances, the resulting arrangement of bars shall be as reviewed and accepted by the Engineer.

K. Welded Wire Reinforcement

1. Welded wire reinforcement placed over horizontal forms shall be supported on slab bolsters.
2. Slab bolsters shall be spaced not more than 30-inch on centers, shall extend continuously across the entire width of the reinforcement mat, and shall support the reinforcement mat in the plane indicated.
3. Welded wire reinforcement placed over the ground shall be supported on wired concrete blocks (dobies) spaced not more than 3 feet on centers in any direction.
4. The construction practice of placing welded wire fabric on the ground and hooking into place in the freshly placed concrete shall not be used.

L. Storage and Handling

1. Epoxy-coated reinforcing bars shall be stored, transported, and placed in such a manner as to avoid chipping of the epoxy coating.
2. Non-abrasive slings made of nylon and similar materials shall be used.
3. Specially coated bar supports shall be used.
4. Chips or cracks in the epoxy coating shall be repaired with a compatible epoxy repair material prior to placing concrete.

M. Accessory Spacing

1. Accessories supporting reinforcing bars shall be spaced such that there is no deflection of the accessory from the weight of the supported bars.
2. When used to space the reinforcing bars from wall forms, the forms and bars shall be located such that there is no deflection of the accessory when the forms are tightened into position.

3.04 SPACING OF BARS

- A. The clear distance between parallel bars (except in columns and between multiple layers of bars in beams) shall be not less than the nominal diameter of the bars, nor less than 1-1/3 times the maximum size of the coarse aggregate, nor less than one inch.
- B. Where reinforcement in beams or girders is placed in 2 or more layers, the clear distance between layers shall be not less than one inch.
- C. In columns, the clear distance between longitudinal bars shall be not less than 1-1/2 times the bar diameter, nor less than 1-1/3 times the maximum size of the coarse aggregate, nor less than 1-1/2 inches.

- D. The clear distance between bars shall also apply to the distance between a contact splice and adjacent splices or bars.

3.05 SPLICING

A. General

1. Reinforcement bar splices shall only be used at indicated locations.
2. When it is necessary to splice reinforcement at points other than where indicated, the character of the splice shall be as reviewed and accepted by the Engineer.
3. Unless otherwise indicated, dowels shall match the size and spacing of the spliced bar.

B. Splices of Reinforcement

1. The length of lap for reinforcement bars, unless otherwise indicated, shall be in accordance with ACI 318 for a Class B splice.
2. Welded Wire Reinforcement
 - a. Laps of welded wire reinforcement shall be in accordance with ACI 318.
 - b. Adjoining sheets shall be securely tied together with No. 14 tie wire, one tie for each 2 running feet.
 - c. Wires shall be staggered and tied in such a manner that they cannot slip.

C. Bending or Straightening

1. Reinforcement shall not be straightened or re-bent in a manner which will injure the material.
2. Bars shall be bent or straight as indicated.
3. Do not use bends different from the bends indicated.
4. Bars shall be bent cold, unless otherwise permitted by the Engineer.
5. No bars partially embedded in concrete shall be field-bent except as indicated or specifically permitted by the Engineer.

D. Couplers

1. Couplers that are located at a joint face shall be of a type that can be set either flush or recessed from the face as indicated.
2. The couplers shall be sealed during concrete placement to completely eliminate concrete, or cement paste from entering.
3. Couplers intended for future connections shall be recessed a minimum of 1/2 inch from the concrete surface.

4. After the concrete is placed, the coupler shall be plugged with plastic plugs which have an O-ring seal and the recess filled with sealant to prevent any contact with water or other corrosive materials.
 5. Threaded couplers shall be plugged.
- E. Unless indicated otherwise, mechanical coupler spacing, and capacity shall match the spacing and capacity of the reinforcing indicated for the adjacent section.

3.06 CLEANING AND PROTECTION

- A. Reinforcement steel shall always be protected from conditions conducive to corrosion until concrete has been placed around it.
- B. The surfaces of reinforcement steel and other metalwork to be in contact with concrete shall be thoroughly cleaned of dirt, grease, loose scale and rust, grout, mortar, and other foreign substances immediately before the concrete is placed.
- C. Where there is delay in depositing concrete, the reinforcement shall be re-inspected and, if necessary, re-cleaned.

3.07 EMBEDMENT OF DRILLED REINFORCING STEEL DOWELS

A. Hole Preparation

1. The hole diameter shall be as recommended by the epoxy manufacturer but shall be no larger than 1/4 inch greater than the diameter of the outer surface of the reinforcing bar deformations.
2. The depth of the hole shall be as recommended by the epoxy manufacturer to fully develop the bar but shall not be less than 12 bar diameters, unless indicated otherwise.
3. The hole shall be drilled by methods that do not interfere with the proper bonding of epoxy.
4. Existing reinforcing steel in the vicinity of proposed holes shall be located prior to drilling, and the location of holes shall be adjusted to avoid drilling through or nicking any existing reinforcing bars. Final hole locations shall be as reviewed and accepted by the Engineer.
5. The hole shall be blown clean with clean, dry compressed air to remove dust and loose particles.

B. Embedment

1. Epoxy shall be injected into the hole through a tube placed to the bottom of the hole.
2. The tube shall be withdrawn as epoxy is placed but kept immersed to prevent formation of air pockets.
3. The hole shall be filled to a depth that ensures excess material will be expelled from the hole during dowel placement.

REINFORCEMENT BARS

4. Dowels shall be twisted during insertion into the partially filled hole so as to guarantee full wetting of the bar surface with epoxy.
5. The bar shall be inserted slowly enough to avoid developing air pockets.

END OF SECTION

SECTION 03 30 00 – CAST-IN-PLACE CONCRETE

PART 1 -- GENERAL

1.01 SUMMARY

- A. Provide cast-in-place concrete, as indicated in accordance with the Contract Documents.
- B. The following types of concrete are covered in this Section:
 - 1. Structural Concrete
 - a. Regular Mix: Use for roof slabs, floor slabs, columns, walls, pavements, and other concrete items not indicated otherwise in the Contract Documents.
 - b. Thick Section Mix: This type of concrete may be used for 12-inch and thicker walls, slabs on grade, pavements, and footings at the Contractor's option.
 - c. Congested Section Mix: Use where indicated or at the Contractor's option, if approved in advance by the Engineer.
 - d. Pea Gravel Mix: Required at the bottom 6 inches of walls with waterstops.
 - 2. Other Concretes
 - a. Sitework Concrete: Concrete to be used for curbs, gutters, catch basins, sidewalks, fence and guard post embedment, underground duct bank encasement, and other concrete appurtenant to electrical facilities, unless otherwise indicated.
 - b. Lean Concrete
 - 1) Concrete to be used for thrust blocks, pipe trench cut-off blocks, and cradles that are indicated as unreinforced
 - 2) Lean concrete shall be used as protective cover for dowels intended for future connections.

1.02 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

A. Reference Specifications

01 33 00	Submittal Procedures
03 01 00	Maintenance of Concrete
03 15 00	Concrete Accessories
07 92 13	Elastomeric Joint Sealants

B. Reference Standards

1. The edition of the standards applicable to the Work shall be those editions referenced by the 2024 Ohio Building Code (OBC). If the standard is not referenced by the OBC, nor an OBC-referenced standard listed below, the edition of the standard applicable to the Work shall be the edition in effect on the date of signing and sealing of the contract specifications.

American Concrete Institute (ACI)	
ACI 117	Specification for Tolerances for Concrete Construction and Materials
ACI 301	Specifications for Structural Concrete
ACI 306.1	Standard Specification for Cold Weather Concreting
ACI 309R	Guide for Consolidation of Concrete
ACI 318	Building Code Requirements for Structural Concrete
ASTM International (ASTM)	
ASTM C31	Standard Practice for Making and Curing Concrete Test Specimens in the Field
ASTM C33	Standard Specification for Concrete Aggregates
ASTM C39	Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens
ASTM C94	Standard Specification for Ready Mixed Concrete
ASTM C127	Standard Test Method for Relative Density (Specific Gravity) and Absorption of Coarse Aggregate
ASTM C128	Standard Test Method for Relative Density (Specific Gravity) and Absorption of Fine Aggregate
ASTM C136	Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates
ASTM C143	Standard Test Method for Slump of Hydraulic-Cement Concrete
ASTM C150	Standard Specification for Portland Cement
ASTM C156	Standard Test Method for Water Loss (from a Mortar Specimen) Through Liquid Membrane-Forming Curing Compounds for Concrete
ASTM C157	Standard Test Method for Length Change of Hardened Hydraulic-Cement Mortar and Concrete
ASTM C192	Standard Practice for Making and Curing Concrete Test Specimens in the Laboratory
ASTM C260	Standard Specification for Air-Entraining Admixtures for Concrete
ASTM C309	Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete
ASTM C494	Standard Specification for Chemical Admixtures for Concrete
ASTM C566	Standard Test Method for Total Evaporable Moisture Content of Aggregate by Drying
ASTM C595	Standard Specification for Blended Hydraulic Cements

ASTM C618	Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete
ASTM C989	Standard Specification for Slag Cement for Use in Concrete and Mortars
ASTM C1012	Standard Test Method for Length Change of Hydraulic-Cement Mortars Exposed to a Sulfate Solution
ASTM C1077	Standard Practice for Agencies Testing Concrete and Concrete Aggregates for Use in Construction and Criteria for Testing Agency Evaluation
ASTM C1116	Standard Specification for Fiber-Reinforced Concrete
ASTM C1157	Standard Performance Specification for Hydraulic Cement
ASTM C1240	Standard Specification for Silica Fume Used in Cementitious Mixtures
ASTM D1227	Standard Specification for Emulsified Asphalt Used as a Protective Coating for Roofing
ASTM D2419	Standard Test Methods for Sand Equivalent Value of Soils and Fine Aggregate

1.03 CONTRACTOR SUBMITTALS

A. Furnish submittals in accordance with Section 01 33 00 – Submittal Procedures

B. Mix Designs

1. Prior to beginning the Work and within 14 Days of the Notice to Proceed, submit preliminary concrete mix designs which shall show the proportions and gradations of materials proposed for each class and type of concrete.
2. Mix designs shall be checked through trial batch and laboratory testing by an independent testing laboratory acceptable to the Engineer.
3. Costs related to trial batch and related laboratory testing shall be Contractor's responsibility as part of the Work.
4. Since laboratory trial batches require 35 calendar days to complete, the Contractor shall test a minimum of 2 mix designs for each class of concrete.

C. Delivery Tickets

1. Where ready-mix concrete is used, the Contractor shall furnish delivery tickets at the time of delivery of each load of concrete.
2. Each ticket shall show the state-certified equipment used for measuring and the total quantities, by weight, of cement, sand, each class of aggregate, admixtures, the amount of water in the aggregate added at the batching plant, and the amount allowed to be added at the Site for the specific design mix.
3. In addition, each ticket shall state the mix number, total yield in cubic yards, and the time of day, to the nearest minute, corresponding to the times when the batch was dispatched, when it left the plant, when it arrived at the Site, when unloading began, and when unloading was finished.

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- D. Test Data: Test data relating to the cement, aggregate, and admixtures shall be less than 6 months old.
 - 1. Test data relating to the certification of ASTM C595 Type IL (MS) blended hydraulic cement for max expansion by ASTM C1012 for sulfate resistance shall be less than 24 months old.
- E. Furnish the following submittals in accordance with ACI 301:
 - 1. mill tests for cement
 - 2. admixture certification, including chloride ion content
 - 3. aggregate gradation test results and certification
 - 4. materials and methods for curing

1.04 CONCRETE CONFERENCE

- A. The Engineer will chair a meeting to review the detailed requirements of the Contractor's proposed concrete design mixes and to determine the procedures for producing proper concrete construction no later than 14 Days after the Notice to Proceed.
- B. Parties involved in the concrete Work shall attend the conference, including the following at a minimum:
 - 1. Contractor's representative
 - 2. testing laboratory representative
 - 3. concrete subcontractor
 - 4. reinforcing steel subcontractor and detailer
 - 5. concrete supplier
 - 6. admixture manufacturer's representative
- C. The conference shall be held at a time and place proposed by the Contractor and accepted by the Engineer.
- D. The conference shall be held at least 5 Days after acceptance.

1.05 QUALITY ASSURANCE

- A. General
 - 1. Tests on component materials and for compressive strength and shrinkage of concrete shall be performed as indicated.
 - 2. Tests for determining slump shall be in accordance with ASTM C143.
 - 3. Testing for aggregate shall include sand equivalence, reactivity, organic impurities, abrasion resistance, and soundness, according to ASTM C33.

4. The cost of trial batch laboratory tests on cement, aggregates, and concrete shall be the Contractor's responsibility.
5. The cost of laboratory tests on field-placed cement, aggregates, and concrete and the cost of Special Inspections required by Code will be the Owner's responsibility.
6. The Contractor shall be responsible for the cost of any tests and investigations of Work that is determined to be Defective Work.
7. The testing laboratory shall meet or exceed ASTM C1077.
8. Concrete for testing shall be furnished by the Contractor, and the Contractor shall assist the Engineer in obtaining samples and disposal and cleanup of excess material.

B. Inspections

1. Continuous inspection by a special inspector approved by the local building department having jurisdiction and by the Engineer will be required where necessary to conform with Code requirements and the Contract Documents.
2. Costs of the special inspector shall be paid by the Owner.
3. Inspection reports shall be submitted to the Engineer.
4. The special inspector shall observe the following for conformance to the Contract Documents:
 - a. the preparation and taking of required test specimens; and,
 - b. placement of concrete, except sitework concrete fully supported on earth.

C. Field Compression Tests

1. Compression test specimens shall be taken during construction from the first placement of each type of concrete and at intervals thereafter as selected by the Engineer to ensure continued compliance with the Specifications.
2. Each set of specimens shall be a minimum of 5 cylinders.
3. Compression test specimens for concrete shall be made in accordance with Section 9.2 of ASTM C31.
4. Specimens shall be 6-inches diameter by 12-inches tall cylinders.
5. Compression tests shall be performed in accordance with ASTM C39.
 - a. One test cylinder shall be tested at 7 Days, and 2 test cylinders tested at 28 Days.
 - b. The remaining cylinders shall be held to verify test results, if needed.

D. Evaluation and Acceptance of Concrete

1. Evaluation and acceptance of the compressive strength of concrete shall be in accordance with ACI 318, ACI 301, and as indicated.
2. A statistical analysis of compression test results shall be performed according to ACI 301.
3. The standard deviation of the test results shall not exceed 640 psi, when ordered at equivalent water content as estimated by slump.
4. If any concrete fails to meet these requirements, immediate corrective action shall be taken to increase the compressive strength for subsequent batches of the type of concrete affected.
5. When the standard deviation of the test results exceeds 640 psi, the average strength for which the mix is designed shall be increased by an amount necessary to satisfy the statistical requirement that the probability of any test being more than 500 psi below or the average of any 3 consecutive tests being below the required compressive strength is 1 in 100.
6. The required average strength shall be calculated in accordance with ACI 301.
7. Concrete that fails to meet the ACI requirements and the indicated requirements is subject to removal and replacement.

E. Shrinkage Tests

1. Drying shrinkage tests shall be performed for the trial batches indicated in the Article below entitled "Trial Batch and Laboratory Tests," for the first placement of each class of structural concrete except pea gravel mix, and during placement to determine continued compliance.
2. Neither structural pea gravel nor structural C-R pea gravel mix need to be tested for shrinkage.
3. Drying shrinkage specimens shall be 4-inch by 4-inch by 11-inch prisms with an effective gauge length of 10-inches, and fabricated, cured, dried, and measured in accordance with ASTM C157, modified as follows:
 - a. Specimens shall be removed from molds at an age of 23 hours, plus or minus one hour, after trial batching, and shall be placed immediately in water at 73 degrees F, plus or minus 3 degrees F, for at least 30 minutes.
 - b. Specimens shall be measured within 30 minutes thereafter to determine original length and then shall be submerged in saturated lime water at 73 degrees F, plus or minus 3 degrees F.
 - c. Measurement to determine expansion expressed as a percentage of original length shall be made at age 7 Days.
 - d. This length at age 7 Days shall be the base length for drying shrinkage calculations ("0" days drying age).

- e. Specimens then shall be stored immediately in a humidity control room maintained at 73 degrees F, plus or minus 3 degrees F, and 50 percent relative humidity, plus or minus 4 percent, for the remainder of the test.
 - f. Measurements to determine shrinkage, expressed as percentage of base length, shall be performed and reported separately for 7, 14, 21, and 28 Days of drying after 7 Days of moist curing.
4. The drying shrinkage deformation of each specimen shall be computed as the difference between the base length (at "0" days drying age) and the length after drying at each test age.
 5. The average drying shrinkage deformation of the specimens shall be computed to the nearest 0.0001 inch at each test age.
 6. If the drying shrinkage of any specimen departs from the average of that test age by more than 0.0004 inch, the results obtained from that specimen shall be disregarded.
 7. Results of the shrinkage test shall be reported to the nearest 0.001 percent of shrinkage.
 8. Compression test specimens shall be taken in each case from the same concrete used for preparing drying shrinkage specimens.
 9. These tests shall be considered a part of the normal compression tests for the project.
 10. Allowable shrinkage limitations are indicated in PART 2 - PRODUCTS, below.
- F. Aggregate Testing: Aggregate testing shall be performed for the trial batch in the Article below entitled "Trial Batch and Laboratory Tests" prior to construction and every 12 months during construction to determine continued compliance.
- G. Construction Tolerances
1. The Contractor shall set and maintain concrete forms and perform finishing operations to ensure that the completed Work is within tolerances.
 2. Surface defects and irregularities are defined as finishes and are different from tolerances.
 3. Tolerance is the permissible variation from lines, grades, or dimensions indicated on the Drawings.
 4. Where tolerances are not indicated, permissible deviations shall be in accordance with ACI 117.
 5. The following non-cumulative construction tolerances apply to finished walls, columns and slabs unless otherwise indicated:

ITEM	TOLERANCE
Variation of the constructed linear outline from the established position in plan.	in 10 feet: 1/4 inch in 20 feet or more: 1/2 inch
Variation from the level or from the grades indicated.	in 10 feet: 1/4 inch in 20 feet or more: 1/2 inch
Variation from plumb	in 10 feet: 1/4 inch in 20 feet or more: 1/2 inch
Variation in the thickness of slabs and walls.	minus 1/4 inch plus 1/2 inch
Variation in the locations and sizes of slabs and wall openings	plus or minus 1/4 inch

PART 2 -- PRODUCTS

2.01 CONCRETE MATERIALS

A. General

- Concrete materials in contact with potable water shall be classified as acceptable for potable water use in accordance with NSF/ANSI 61 as required by the authority having jurisdiction. Not all products listed herein are for use in contact with potable water.
- Cement for concrete that will contact potable water shall not be obtained from kilns that burn metal rich hazardous waste fuel.
- Materials shall be delivered, stored, and handled so as to prevent damage by water or breakage.
- Cement reclaimed from cleaning bags or leaking containers shall not be used.
- Cement shall be used in the sequence of receipt of shipments.
- Materials and storage of materials shall comply with ACI 301, as applicable.

B. Materials for concrete shall conform to the following requirements:

- Cement
 - Cement shall be ASTM C595 Type IL (MS) blended hydraulic cement.
 - A minimum of 85 percent of cement by weight shall pass a 325 screen.
 - A single brand of cement shall be used throughout the Work, and prior to its use, the brand shall be accepted by the Engineer.
 - The cement shall be suitably protected from exposure to moisture until used.
 - Cement that has become lumpy shall not be used.
 - Sacked cement shall be stored in such a manner so as to permit access for inspection and sampling.

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- g. Certified mill test reports, including fineness, for each shipment of cement to be used shall be submitted to the Engineer, if requested, regarding compliance with the Specifications.
- 2. Water
 - a. Water for mixing and curing shall be potable, clean, and free from objectionable quantities of silty organic matter, alkali, salts, and other impurities.
 - b. The water shall be considered potable, for the purposes of this Section only, if it meets the requirements of the local governmental agencies.
 - c. Agricultural water with high total dissolved solids (greater than 1000 mg/L TDS) shall not be used.
- 3. Aggregates
 - a. Aggregates shall be obtained from pits acceptable to the Engineer, shall be non-reactive, and shall conform to ASTM C33.
 - b. The maximum size of coarse aggregate shall be as indicated, and the substitution of lightweight sand for fine aggregate will not be permitted.
 - c. Coarse Aggregates
 - 1) Coarse aggregates shall consist of clean, hard, durable gravel, crushed gravel, crushed rock, or a combination thereof.
 - 2) The coarse aggregates shall be prepared and handled in 2 or more size groups for combined aggregates, with a maximum size greater than 3/4 inch.
 - 3) When the aggregates are proportioned for each batch of concrete, the 2 size groups shall be combined (also refer to the Article below entitled "Trial Batch and Laboratory Tests").
 - d. Fine Aggregates
 - 1) Fine aggregates shall be natural sand or a combination of natural and manufactured sand that is hard and durable.
 - 2) When tested in accordance with ASTM D2419, the sand equivalency shall not be less than 75 percent for an average of 3 samples, nor less than 70 percent for an individual test.
 - 3) The gradation of fine aggregate shall conform to ASTM C33 when tested in accordance with ASTM C136 for the fineness modulus of the sand used, including the optional grading in Section 6.2.
 - 4) The fineness modulus of sand used shall not be greater than 3.1.
 - 5) When tested in accordance with ASTM C33, the fine aggregate shall produce a color in the supernatant liquid no darker than the reference standard color solution.

- e. Combined Aggregates
 - 1) Combined aggregates shall be well graded from coarse to fine sizes and shall be uniformly graded between screen sizes to produce concrete that has optimum workability and consolidation characteristics.
 - 2) Where a trial batch is required for a mix design, the final combined aggregate gradations will be established during the trial batch process.
 - 3) When tested in accordance with ASTM C33, the coarse aggregate shall show a loss not exceeding 42 percent after 500 revolutions or 10.5 percent after 100 revolutions.
- f. When tested in accordance with ASTM C33, the ratio of silica released to reduction in alkalinity shall not exceed 1.0.
- g. When tested in accordance with ASTM C33, the loss resulting after 5 cycles of the soundness test shall not exceed 10 percent for fine aggregate and 12 percent for coarse aggregate when using sodium sulfate.
- 4. Ready-mixed concrete shall conform to the requirements of ASTM C94.
- 5. Admixtures
 - a. Admixtures shall be compatible and shall be furnished by a single manufacturer capable of providing qualified field service representation.
 - b. Admixtures shall be used in accordance with manufacturer's recommendations.
 - c. If the use of an admixture is producing an inferior end result, the Contractor shall discontinue use of the admixture.
 - d. Admixtures shall not contain thiocyanates nor more than 0.05 percent chloride ion, and shall be non-toxic after 30 days.
- e. Air Content
 - 1) An air-entraining agent meeting the requirements of ASTM C260 shall be used.
 - 2) Concrete floors to receive a dry-shake floor hardener shall have an air content not to exceed 3 percent.
 - 3) The Owner reserves the right, at any time, to sample and test the air-entraining agent.
 - 4) The air-entraining agent shall be added to the batch in a portion of the mixing water.
 - 5) The solution shall be batched by means of a mechanical batcher capable of accurate measurement.
 - 6) Air content shall be tested at the point of placement.

- 7) The air entraining agent shall be Micro-Air by Master Builders; Daravair by W.R. Grace; Sika AEA-15 by Sika Corporation; or equal
- f. Set-Controlling and Water-Reducing Admixtures
- 1) Admixtures may be added at the Contractor's option, subject to the Engineer's approval, to control the set, effect water reduction, and increase workability.
 - 2) The cost of adding an admixture shall be the Contractor's responsibility.
 - 3) Concrete containing an admixture shall be first placed at a location determined by the Engineer.
 - 4) Admixtures shall conform to ASTM C494.
 - 5) The required quantity of cement shall be used in the mix regardless of whether or not an admixture is used.
 - 6) Concrete shall not contain more than one water-reducing admixture, unless it can be demonstrated that the proposed mix will meet the indicated drying shrinkage requirements.
 - 7) The set-controlling admixture may be either with or without water-reducing properties.
 - 8) Where the air temperature at the time of placement is expected to be consistently greater than 80 degrees F, a set-retarding admixture such as Plastocrete 161MR by Sika Corporation, Pozzoloth or Delvo by BASF, Daratard by W.R. Grace, or equal shall be used.
 - 9) Where the air temperature at the time of placement is expected to be consistently less than 40 degrees F, a non-corrosive set accelerating admixture such as Plastocrete 161FL by Sika Corporation, MasterSet FP 20 by BASF, Daraset by W.R. Grace, or equal shall be used.
- 10) Mid-Range Water Reducers
- a) General use water-reducing admixtures shall be mid-range and shall conform to ASTM C494, Type A and F.
 - b) Use Daracem by W.R. Grace, Polyheed by BASF, Sikament by Sika Corporation, or equal.
 - c) The quantity of admixture used and the method of mixing shall be in accordance with the manufacturer's instructions and recommendations.
- 11) High-Range Water Reducers
- a) High-range water reducers shall conform to ASTM C494, Type F or G.
 - b) Use ADVA by W.R. Grace, ViscoCrete by Sika Corporation, Glenium by BASF, or equal.

- c) The high-range water reducer shall be added to the concrete after all other ingredients have been mixed and initial slump has been verified.
- d) No more than 14 ounces of water reducer per sack of cement shall be used.
- e) The water reducer shall be considered as part of the mixing water when calculating the water/cement ratio.
- f) If the high-range water reducer is added to the concrete at the Site, it may be used in conjunction with the same water reducer added at the batch plant.
- g) Concrete shall have a slump of 3 inches, plus or minus 1/2 inch, prior to adding the high-range water reducing admixture at the Site.
- h) The high-range water reducing admixture shall be accurately measured and pressure injected into the mixer as a single dose by an experienced technician.
- i) A standby system shall be provided and tested prior to each day's operation of the primary system.
- j) Concrete shall be mixed at mixing speed for a minimum of 70 mixer revolutions or 5 minutes after the addition of the high-range water reducer, unless recommended otherwise by the manufacturer.

g. Other Admixtures

1) Flyash

- a) Fly ash may be substituted for not more than 15 percent, by weight, of cement in structural concrete and not more than 30 percent, by weight, for sitework concrete, and not more than 50 percent, by weight, of cement in other concrete.
- b) Fly ash shall conform to ASTM C618 and shall not have loss-on-ignition greater than 3 percent.
- c) The water/cement ratio shall be calculated based on cement plus fly ash.

2) Ground Blast Furnace Slag Cement

- a) Slag cement shall conform to ASTM C989, Grade 100 or 120.
- b) Blended cements shall conform to ASTM C595, Type 1S, or ASTM C1157.
- c) Slag cement substitution, if used, shall be not less than 25, nor more than 50 percent by weight of cement.
- d) Slag cement substitution shall not be used with fly ash substitution.

- e) The water/cement ratio shall be calculated based on cement plus slag cement.
- 3) Fiber reinforcing
 - a) Fiber-reinforced concrete shall be furnished where indicated.
 - b) Fiber reinforcement shall be synthetic fiber reinforcement.
 - c) Use Fibermesh 300, as manufactured by Propex, or equal.
 - d) Fiber reinforcing shall be batched at the plant at a rate of 1.5 pounds per cubic yard of concrete.
 - e) Material: 100-percent virgin homopolymer polypropylene-fibrillated fibers; containing no reprocessed olefin materials
 - f) Conformance: ASTM C1116, Type III
 - g) Fire Classifications: UL Report File No. R8534-11; Southwest Certification Services (SWCS), Omega Point Laboratories No. 8662-1
 - h) Fiber Length: one inch
 - i) Alkali Resistance: alkali-proof
 - j) Absorption: nil
 - k) Specific Gravity: 0.91
 - l) Melting Point: 324 degrees F (162 degrees C)

2.02 CURING MATERIALS

- A. General: Curing compounds shall be resin-based and shall be compliant with local VOC requirements, unless otherwise indicated herein.
- B. Regular Curing Compound
 - 1. Regular curing compound shall be white-pigmented and shall conform to ASTM C309, Type 2, Class B.
 - 2. Sodium silicate compounds will not be accepted.
 - 3. The concrete curing compound shall be:
 - a. Kurez VOX White Pigmented by Euclid Chemicals Company;
 - b. L&M Cure R-2 by L&M Construction Chemicals;
 - c. 1200-White by W.R. Meadows;
 - d. Kure-N-Seal WB White Pigmented by Sonneborn/Degussa Building Systems;
 - e. or equal.

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C. Dissipating Curing Compound

1. When the curing compound must be removed for finishes or grouting, compounds shall be of a dissipating type, conforming to ASTM C309, Type 1 or 2, Class B.
2. The dissipating curing compound shall be:
 - a. Korez DR VOX by Euclid Chemical Company;
 - b. L&M Cure R-2 by L & M Construction Chemicals;
 - c. 1100-Clear by W.R. Meadows;
 - d. or equal.

D. Curing Compound for Applications Requiring NSF/ANSI 61 Compliance

1. When the curing compound is required to conform to NSF/ANSI 61, the curing compound shall be water-based and shall be compliant with all local VOC requirements; shall conform to ASTM C309; and shall be certified to conform to the requirements of NSF/ANSI 61.
2. The NSF/ANSI 61 Certified curing compound shall be:
 - a. E-Cure by SpecChem, LLC;
 - b. Atlas Quantum-Cure NSF by Atlas Tech Products;
 - c. or equal.

E. Concrete Curing Blanket

1. Polyethylene Sheets
 - a. Polyethylene sheets for use as concrete curing blanket shall be white and shall have a nominal thickness of 6 mils.
 - b. The loss of moisture when determined in accordance with ASTM C156 shall not exceed 0.055 grams per square centimeter of surface.
2. Polyethylene-Coated Waterproof Paper
 - a. Polyethylene-coated waterproof paper sheeting for use as concrete curing blanket shall consist of white polyethylene sheeting free of visible defects, uniform in appearance, shall have a nominal thickness of 2-mils, and shall be permanently bonded to waterproof paper conforming to the requirements of Federal Specification UU-B-790A – Building Paper, Vegetable Fiber (Kraft, Waterproofed, Water Repellant and Fire Resistant).
 - b. The loss of moisture, when determined in accordance with ASTM C156, shall not exceed 0.055 gram per square centimeter of surface.
3. Polyethylene-Coated Burlap

- a. Polyethylene-coated burlap for use as concrete curing blanket shall be 4 mils thick, with white opaque polyethylene film impregnated or extruded into one side of the burlap.
- b. The burlap shall weigh not less than 9 ounces per square yard.
- c. The loss of moisture, when determined in accordance with ASTM C156, shall not exceed 0.055 grams per square centimeter of surface.

F. Curing Mats

1. Curing mats for use in Curing Method 6, below, shall be heavy shag rugs or carpets or cotton mats quilted at 4 inches on center.
2. Curing mats shall weigh a minimum of 12 ounces per square yard when dry.

2.03 NON-WATERSTOP JOINT MATERIALS

A. Materials for non-waterstop joints in concrete shall conform to the following requirements:

1. The preformed joint filler shall be a non-extruding neoprene sponge or polyurethane type conforming to Section 03 15 00 – Concrete Accessories.
2. The elastomeric joint sealer shall conform to Section 07 92 13 – Joint Sealants.

3. Mastic Joint Sealer

- a. The mastic joint sealer shall be a material:
 - 1) that does not contain evaporating solvents;
 - 2) that will tenaciously adhere to concrete surfaces;
 - 3) that will remain permanently resilient and pliable;
 - 4) that will not be affected by the continuous presence of water;
 - 5) that will not in any way contaminate potable water;
 - 6) and that will effectively seal the joints against moisture infiltration even when the joints are subject to movement from expansion and contraction.
- b. The sealer shall be composed of special asphalts or similar materials blended with lubricating and plasticizing agents to form a tough, durable mastic substance containing no volatile oils or lubricants.
- c. The sealer shall be capable of meeting the indicated test requirements if testing is required by the Engineer.

2.04 MISCELLANEOUS MATERIALS

A. Dampproofing Agent

1. The dampproofing agent shall be an asbestos-free, fibered asphalt emulsion intended for cold application to green concrete, both above- and below-grade.

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2. Dampproofing shall meet the requirements of ASTM D1227, Type II, Class I.

3. Dampproofing shall be:

- a. Hydrocide 700 Series by Sonneborn/Degussa Building Systems;
- b. Sealmastic by W. R. Meadows;
- c. HE 789 by Henry Company;
- d. or equal.

B. Bonding Agents

1. Bonding agents shall be epoxy adhesives.

2. Bonding agents for bonding freshly-mixed, plastic concrete to hardened concrete shall be:

- a. Sikadur 32 Hi-Mod Epoxy Adhesive by Sika Corporation;
- b. MasterEmaco ADH 326 by BASF/Master Builders;
- c. BurkEpoxy MV by Edoco;
- d. or equal.

3. Bonding agents for bonding hardened concrete or masonry to steel shall be:

- a. Sikadur 31 Hi-Mod Gel by Sika Corporation;
- b. BurkEpoxy NS by Edoco;
- c. Concreive Paste (LPL) by MBT/Degussa Building Systems;
- d. or equal.

C. Colorant for duct bank concrete shall be an integral red oxide coloring pigment used in the proportion of 8 pounds per cubic yard of concrete.

D. Form liners at construction joints (non-architectural)

1. Form liners used at construction joints shall produce a minimum 1/4" amplitude roughened surface. Surface profiles designated using the International Concrete Repair Institute concrete surface profiles (CSP) shall achieve a CSP 10 roughness.

2.05 CONCRETE DESIGN REQUIREMENTS

A. General

- 1. Concrete shall be composed of cement, admixtures, aggregates, and water of the qualities indicated.
- 2. The exact proportions in which these materials are to be used for different parts of the Work shall be determined during the trial batches.

3. In general, the mix shall be designed to produce a concrete capable of being deposited to obtain maximum density and minimum shrinkage, and, where deposited in forms, to have good consolidation properties and maximum smoothness of surface.
4. The aggregate gradations shall be formulated to provide fresh concrete that will not promote rock pockets around reinforcing steel or embedded items.
5. The proportions shall be changed whenever necessary or desirable to meet the required results, and such changes shall be subject to review by the Engineer.

B. Fine Aggregate Composition

1. In mix designs for structural concrete, except for 1/2-inch and 3/8-inch maximum size aggregate, the percentage of fine aggregate in total aggregate by weight shall be as indicated in the following table:

Fine Aggregate	
Fineness Modulus	Percent (maximum)
2.7 or less	41
2.7 to 2.8	42
2.8 to 2.9	43
2.9 to 3.1	44

2. For other concrete, the maximum percentage of fine aggregate of total aggregate by weight shall not exceed 50 percent.

C. Duct Bank Concrete

1. Duct bank concrete shall contain an integral red-oxide coloring pigment.
2. The concrete shall be dyed red throughout.
3. Using a surface treatment to color duct banks will not be accepted.

D. Water/Cement Ratio

1. The indicated water/cement ratio is for a saturated-surface dry condition of aggregate.
2. Throughout every Day, the added batch water shall be adjusted for the total free water in the aggregates, which shall be determined as follows:
 - a. The total moisture content of all aggregate shall be calculated by ASTM C566.
 - b. Subtract the moisture absorbed by the coarse aggregate, calculated by ASTM C127.
 - c. Subtract the moisture absorbed by the fine aggregate, calculated by ASTM C128.

E. Concrete Property Tables

1. The maximum cement contents, the maximum W/C Ratios and the maximum Water Contents given in the Concrete Property Tables below are intended to minimize drying shrinkage and heat of hydration of the concrete.
2. It is understood that the indicated maximum cement contents and maximum water contents may require additional water reducing agent for the workability required by the Contractor's methods, and may not result in the least costly concrete mix for the required concrete strength.

STRUCTURAL CONCRETE				
Type of WORK	Regular Mix (roof, floor slabs, walls, pavements, and other concrete items not categorized elsewhere)	Thick Section Mix (12-inch and thicker walls, slabs on grade, pavements, and footings)	Congested Section Mix (Use where indicated or at the CONTRACTOR's option if approved in advance by the ENGINEER)	Pea Gravel Mix (concrete at the bottom 6 inches of waterstopped walls) At the CONTRACTOR's option, superplastic Regular Mix may be substituted for the first lift
Min 28 Day Compressive Strength, psi	4500	4500	5000	5000
Max Aggregate Size, in	1	1-1/2	1/2	3/8
Cementitious material content per cubic yard, lb, minimum	564	564	600	658
Cementitious material content per cubic yard, lb, maximum	658	658	658	752
Water content per cubic yard, lb, maximum	254	254	240	301
Max W/C Ratio by weight	0.42	0.42	0.40	0.40
Total Air Content, percent	4.5 to 7.5	4 to 7	5.5 to 8.5	6 to 9
Slump	4 inches +/- 1 in with high-range water reducer: 7 inches +/- 2 in	4 inches +/- 1 in with high-range water reducer: 7 inches +/- 2 in	with high-range water reducer: 7 inches +/- 2 in	with high-range water reducer: 7 inches +/- 2 in

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OTHER CONCRETE		
Type of Work	Sitework Concrete (curbs, gutters, sidewalks, catch basins, fence embedments, encasements, and ductbanks)	Lean Concrete (thrust blocks, pipe trench cut-off blocks, and cradles)
Min 28 Day Compressive Strength, psi	3000	2000
Max Aggregate Size, in	1	1
Cementitious material content per cubic yard, lb, minimum	470	376
Cementitious material content per cubic yard, lb, maximum	564	450
Water content per cubic yard, lb, maximum	254	270
Max W/C Ratio by weight	0.45	0.60
Total Air Content, percent	4 to 7	4.5 to 7.5
Slump	4 inches +/- 1 in ductbanks and encasements: 5 inches +/- 1 in	4 inches +/- 1 in

NOTE: The Contractor is cautioned that the limiting parameters above are not a mix design. Admixtures may be required to achieve workability required by the Contractor's construction methods and aggregates. The Contractor shall be responsible for providing concrete with the required workability and strength.

F. Adjustments to Mix Design

1. The Contractor may elect to decrease the water/cement ratio to achieve the strength and shrinkage requirements and/or add water reducers, as required to achieve workability.
2. The mixes shall be changed whenever such change is necessary or desirable to secure the required strength, density, workability, and surface finish, and the Contractor shall be entitled to no additional compensation because of such changes.

3. Any changes to the accepted concrete mix design shall be submitted to the Engineer for review and shall be tested again in accordance with the indicated requirements.

2.06 CONSISTENCY

- A. The quantity of water in a batch of concrete shall be just sufficient, with a normal mixing period, to produce a concrete that can be worked properly into place without segregation and which can be compacted by vibratory methods to give the desired density, impermeability, and smoothness of surface.
- B. The quantity of water shall be changed as necessary, with variations in the nature or moisture content of the aggregates, in order to maintain uniform production of a desired consistency.
- C. The consistency of the concrete in successive batches shall be determined by slump tests in accordance with ASTM C143.
- D. The slumps shall be as indicated with the concrete properties.

2.07 TRIAL BATCH AND LABORATORY TESTS

- A. The Contractor shall only use a mix design for construction that has first met the trial batch testing requirements.
- B. Before placing any concrete, a testing laboratory selected by the Engineer shall prepare a trial batch of each class of structural concrete, based on the preliminary concrete mixes submitted by the Contractor.
- C. Aggregate Proportions
 1. During the trial batch the aggregate proportions may be adjusted by the testing laboratory using the two coarse aggregate size ranges to obtain the required properties.
 2. If one size range produces an acceptable mix, a second size range need not be used.
 3. Such adjustments will be considered refinements to the mix design and will not be the basis for extra compensation to the Contractor.
 4. Concrete shall conform to the indicated requirements whether the aggregate proportions are from the Contractor's preliminary mix design or whether the proportions have been adjusted during the trial batch process.
 5. The trial batch shall be prepared using the aggregates, cement, and admixture proposed for the project.
- D. The trial batch materials shall be of a quantity such that the testing laboratory can obtain 3 drying shrinkage and 6 compression test specimens from each batch.
- E. The determination of compressive strength shall be made by testing 6-inch diameter by 12-inch high cylinders, which have been made, cured, and tested in accordance with ASTM C192 and ASTM C39.

- F. The testing schedule shall be 3 compression test cylinders tested at 7 Days and 3 at 28 Days.
- G. The average compressive strength for the 3 cylinders tested at 28 Days for any given trial batch shall be not less than the required average compressive strength indicated below:

Specified compressive strength f'_c (psi)	Required average compressive strength f'_{cr} (psi)
Less than 3000	$f'_c + 1000$
3000 to 5000	$f'_c + 1200$
Over 5000	$1.1f'_c + 700$

- H. A sieve analysis of the combined aggregate for each trial batch shall be performed according to the requirements of ASTM C136, and values shall be provided for percent passing each sieve.

2.08 SHRINKAGE LIMITATION

A. General

1. The Contractor shall only use a mix design for construction that has first met the trial batch shrinkage requirements.
2. Shrinkage limitations shall apply only to structural concrete.

B. Maximum Shrinkage

1. The maximum concrete shrinkage for specimens cast in the laboratory from the trial batch, as measured at 21-Day drying age or at 28-Day drying age, shall be 0.036 percent or 0.042 percent, respectively.
2. Standard deviation will not be considered.
3. The maximum concrete shrinkage for specimens cast in the field shall not exceed the trial batch maximum shrinkage requirement by more than 25 percent.

- C. If the required shrinkage limitation is not met during construction, the Contractor shall take any or all of the following actions to reestablish compliance:

1. changing the source of aggregates, cement and/or admixtures;
2. reducing water/cement ratio;
3. washing of coarse and/or fine aggregate to reduce fines;
4. increasing the number of construction joints;
5. modifying the curing requirements; or
6. other actions to minimize shrinkage or the effects of shrinkage.

2.09 MEASUREMENT OF CEMENT AND AGGREGATE

A. The amount of cement and of each separate size of aggregate entering into each batch of concrete shall be determined by direct weighing equipment furnished by the Contractor and acceptable to the Engineer.

B. Weighing Tolerances

Material	Percent of Total Weight
Cement	1
Aggregates	3
Admixtures	3

2.10 MEASUREMENT OF WATER

A. The quantity of water entering the mixer shall be measured by a suitable water meter or other measuring device of a type acceptable to the Engineer and capable of measuring the water in variable amounts within a tolerance of one percent.

B. The water feed control mechanism shall be capable of being locked in position in order to constantly deliver the required amount of water to each batch of concrete.

C. A positive, quick-acting valve shall be used for a cut-off in the water line to the mixer, and the operating mechanism shall prevent leakage when the valve is closed.

2.11 READY-MIXED CONCRETE

A. General

1. At the Contractor's option, ready-mixed concrete may be used if it meets the indicated requirements as to materials, batching, mixing, transporting and placement, and is in accordance with ASTM C94 and the following supplementary requirements.
2. Ready-mixed concrete shall be delivered to the Work, and discharge shall be completed within one hour after the addition of the cement to the aggregates or before the drum has been revolved 250 revolutions, whichever occurs first.
3. The use of non-agitating equipment for transporting ready-mixed concrete will not be permitted.
4. Combination truck and trailer equipment for transporting ready-mixed concrete will not be permitted.
5. The quality and quantity of materials used in ready-mixed concrete and in batch aggregates shall be subject to continuous inspection at the batching plant by the Engineer.

B. Counters

1. Truck mixers shall be equipped with electrically-actuated counters by which the number of revolutions of the drum or blades may be readily verified.

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2. The counter shall be of the resettable, recording type and shall be mounted in the driver's cab.
3. The counters shall be actuated at the time of starting the mixers at mixing speeds.

C. Mixing

1. Each batch of concrete shall be mixed in a truck mixer for not less than 70 revolutions of the drum or blades at the rate of rotation designated by the manufacturer of equipment.
2. Additional mixing, if any, shall be at the speed designated by the manufacturer of the equipment as agitating speed.
3. Materials, including the mixing water, shall be in the mixer drum before actuating the revolution counter for determining the number of revolutions of mixing.

D. Uniformity

1. Truck mixers and their operation shall be such that the concrete throughout the mixed batch as discharged is within acceptable limits of uniformity with respect to consistency, mix, and grading.
2. If slump tests taken at approximately the 1/4- and 3/4-point of the load during discharge result in slumps differing by more than one inch when the required slump is 3 inches or less, or if they differ by more than 2 inches when the required slump is more than 3 inches, the mixer shall not be used on the Work unless the causative condition is corrected and satisfactory performance is verified by additional slump tests.
3. Mechanical details of the mixer, such as water measuring and discharge apparatus, condition of the blades, speed of rotation, general mechanical condition of the unit, and clearance of the drum, shall be checked before a further attempt to use the unit will be permitted.

- E. Each batch of ready-mixed concrete delivered to the Site shall be accompanied by a delivery ticket that is furnished to the Engineer in accordance with the Paragraph in Part 1 of this Section entitled "Delivery Tickets."

PART 3 -- EXECUTION

3.01 PROPORTIONING AND MIXING

- A. Proportioning of the mix shall conform to ACI 301.
- B. Mixing shall conform to ACI 301.
- C. Slumps shall be as indicated.
- D. Re-tempering of concrete or mortar that has partially hardened will not be permitted.

3.02 PREPARATION OF SURFACES FOR CONCRETING

A. General

1. Earth surfaces shall be thoroughly wetted by sprinkling prior to the placing of any concrete, and these surfaces shall be kept moist by frequent sprinkling up to the time of placing concrete thereon.
2. The surface shall be free from standing water, mud, and debris at the time of placing concrete.

B. Joints in Concrete

1. Construction joints are defined as concrete surfaces upon which or against which concrete is to be placed, but placement of concrete has been stopped or interrupted and the Engineer has determined that the new concrete cannot be incorporated integrally with the concrete previously placed.
2. The surfaces of horizontal joints shall be given a compacted, roughened surface for good bonding.
3. Except where coated joint surfaces have been indicated, the joint surfaces shall be cleaned of laitance, loose or defective concrete, foreign material, and be roughened to a minimum 1/4-inch amplitude.
4. Cleaning and roughening shall be accomplished by hydroblasting or sandblasting (exposing aggregate) followed by thorough washing. Roughening may also be accomplished through the use of form liners as indicated in Part 2 of this specification.
5. Pools of water shall be removed from the surface of construction joints before the new concrete is placed.
6. Pea gravel concrete mix
 - a. After the surfaces have been prepared, each approximately horizontal construction joint (except at the top of walls) shall be covered with a 6-inch lift of a pea gravel mix.
 - b. The pea gravel concrete mix shall be placed and spread uniformly.
 - c. Wall concrete shall follow immediately and shall be placed upon the fresh pea gravel mix.

C. Placement Interruptions

1. When placing of concrete is to be interrupted long enough for the concrete to take a set, the working face shall be given a shape by the use of forms or other means that will secure proper union with subsequent Work.
2. Such construction joints shall be made only where acceptable to the Engineer.

D. Embedded Items

1. No concrete shall be placed until the formwork, the installation of parts to be embedded, the reinforcement steel, and the preparation of surfaces involved in the placing have been completed and accepted by the Engineer at least 4 hours before the placement of concrete.
2. Surfaces of forms and embedded items that have become encrusted with dried grout from previous usage shall be cleaned before the surrounding or adjacent concrete is placed.
3. Inserts or other embedded items shall conform to the indicated requirements.
4. Reinforcement, anchor bolts, sleeves, inserts, and similar items shall be set and secured in the forms at locations as indicated or shown by Shop Drawings, and shall be acceptable to the Engineer before any concrete is placed.
5. Accuracy of placement shall be the responsibility of the Contractor.

E. Casting New Concrete Against Old Concrete

1. Where concrete is to be cast against old concrete (defined as any concrete which is greater than 60 Days old), the surface of the old concrete shall be thoroughly cleaned and roughened by hydroblasting or sandblasting to expose aggregate.
2. The joint surface shall be coated with an epoxy bonding agent unless determined otherwise by the Engineer.

F. Water

1. No concrete shall be placed in any structure until water entering the space to be filled with concrete has been properly cut off or has been diverted by pipes or other means, and carried out of the forms, clear of the Work.
2. No concrete shall be deposited underwater nor shall the Contractor allow still water to rise on any concrete until the concrete has attained its initial set.
3. Water shall not be permitted to flow over the surface of any concrete in such manner and at such velocity as will injure the surface finish of the concrete.
4. Pumping or other necessary dewatering operations for removing ground water, if required, shall be subject to review by the Engineer.

G. Corrosion Protection

1. Pipe, conduit, dowels, and other ferrous items required to be embedded in concrete construction shall be positioned and supported prior to placement of concrete such that there will be a minimum of 2 inches clearance between said items and any part of the concrete reinforcement.
2. Securing such items in position by wiring or welding them to the reinforcement will not be permitted.

H. Openings for pipes, inserts for pipe hangers and brackets, and anchors shall be provided, where practicable, during the placement of concrete.

- I. Anchor bolts shall be accurately set and shall be maintained in position by templates while embedded in the concrete.
- J. Cleaning: The surfaces of metalwork to be in contact with the concrete shall be thoroughly cleaned of dirt, grease, loose scale and rust, grout, mortar, and other foreign substances immediately before the concrete is placed.

3.03 HANDLING, TRANSPORTING, AND PLACING

A. General

- 1. The placement of concrete shall conform to the applicable portions of ACI 301 and the indicated requirements.
- 2. No aluminum materials shall be used in conveying any concrete.

B. Non-Conforming Work or Materials

- 1. Concrete which during or before placing is found not to conform to the indicated requirements will be rejected and shall be immediately removed from the Work.
- 2. Concrete that is not placed in accordance with these requirements or which is of inferior quality shall be removed and replaced.

C. Unauthorized Placement

- 1. No concrete shall be placed except in the presence of an authorized representative of the Engineer.
- 2. The Contractor shall notify the Engineer in writing at least 24 hours in advance of the placement of any concrete.

D. Casting New Concrete Against Old

- 1. An epoxy adhesive bonding agent shall be applied to the old surfaces according to the manufacturer's written recommendations.
- 2. This provision shall not apply to joints where waterstop has been provided.
- 3. Refer to Section 03 15 00 – Concrete Accessories, for other requirements.

E. Conveyor Belts and Chutes

- 1. Ends of chutes, hopper gates, and other points of concrete discharge throughout the Contractor's conveying, hoisting, and placement system shall be designed and arranged such that concrete passing from them will not fall separated into whatever receptacle immediately receives it.
- 2. Conveyor belts, if used, shall be of a type acceptable to the Engineer.
- 3. Chutes longer than 50 feet will not be permitted.
- 4. The minimum slopes of chutes shall be such that concrete of the indicated consistency will readily flow in them.

5. If a conveyor belt is used, it shall be wiped clean by a device operated in such a manner that none of the mortar adhering to the belt will be wasted.
6. Conveyor belts and chutes shall be covered.

F. Placement in Wall and Column Forms

1. Concrete shall not be dropped through reinforcement steel or into any deep form, nor shall concrete be placed in any form in such a manner as to leave accumulation of mortar on the form surfaces above the placed concrete.
2. In such cases, means such as hoppers and, if necessary, vertical ducts of canvas, rubber, or metal shall be used for placing concrete in the forms in a manner that it may reach the place of final deposit without separation.
3. In no case shall the free fall of concrete below the ends of ducts, chutes, or buggies exceed 4 feet in walls and 8 feet in columns.
4. Concrete shall be uniformly distributed during the process of deposition, and in no case after deposition shall any portion be displaced in the forms more than 6 feet in the horizontal direction.
5. Concrete in wall forms shall be deposited in uniform horizontal layers not deeper than 2 feet, and care shall be exercised to avoid inclined layers or inclined construction joints except where such are required for sloping members.
6. Each layer shall be placed while the previous layer is still soft.
7. The rate of placing concrete in wall forms shall not exceed 5 feet of vertical rise per hour.
8. Sufficient illumination shall be provided in the interior of forms such that the concrete at the places of deposit is visible from the deck or runway.

G. Placement in Slabs

1. Concrete placement in sloping slabs shall proceed uniformly from the bottom of the slab to the top for the full width of the placement.
2. As the Work progresses, the concrete shall be vibrated and carefully worked around the slab reinforcement, and the surface of the slab shall be screeded in an up-slope direction.

H. Temperature of Concrete

1. The temperature of concrete when it is being placed shall be not more than 90 degrees F nor less than 50 degrees F.
2. For sections less than 12 inches thick, the temperature of concrete when placed shall be not less than 55 degrees F.

I. Hot or Cold Weather Procedures

1. If required by the Engineer, the Contractor shall submit detailed procedures for the production, transportation, placement, protection, curing, and temperature monitoring of concrete during hot or cold weather.
2. The submittal shall include procedures to be implemented upon abrupt changes in weather conditions or equipment failures.
3. The Contractor shall not be entitled to additional compensation for satisfying the hot weather placement or the cold weather placement requirements below.

J. Hot Weather Placement

1. If the temperature of the concrete is 85 degrees F or greater, the time between introducing the cement into the aggregates and discharge shall not exceed 45 minutes.
2. If the concrete is placed when the weather is such that the temperature of the concrete would exceed 90 degrees F, the Contractor shall employ effective means such as pre-cooling of aggregates, using ice as mixing water, or placing at night as necessary to maintain the temperature of the concrete below 90 degrees F as it is placed.
3. During the curing period, the maximum temperature decrease measured at the surface of the concrete shall not exceed 50 degrees F in 24 hours nor 5 degrees F in one hour.

K. Cold Weather Placement

1. The placement of concrete shall conform to ACI 306.1 and the following requirements:
 - a. Remove snow, ice, and frost from the surfaces, including reinforcement, against which concrete is to be placed.
 - b. Before beginning concrete placement, thaw the subgrade to a minimum depth of 6 inches.
 - c. Reinforcement and embedded items shall be warmed to above 32 degrees F prior to concrete placement.
 - d. Maintain the concrete temperature above 50 degrees F for at least 72 hours after placement.
 - e. Concrete ingredients shall not be heated more than necessary to prevent the temperature of the mixed concrete, as placed, from falling below the minimum temperature criterion.

3.04 PUMPING OF CONCRETE

- A. General: If the pumped concrete does not produce satisfactory end results, the Contractor shall discontinue the pumping operation and proceed with the placing of concrete using conventional methods.
- B. Pumping Equipment

1. The pumping equipment shall have 2 cylinders and shall be designed to operate with one cylinder in case the other one is not functioning.
 2. In lieu of this requirement, the Contractor may have a standby pump on the Site during pumping.
 3. The minimum diameter of the hose conduits shall be 4 inches, unless approved otherwise by the Engineer.
 - a. For thin walls and columns and other elements which do not have sufficient clear space to accommodate a 4 inch diameter conduit, the Contractor shall submit details for a smaller diameter conduit along with confirmation that the smaller conduit can functionally place the approved concrete mix in accordance with the Concrete Specifications.
 4. Pumping equipment and hose conduits that are not functioning properly shall be replaced.
 5. Aluminum conduits for conveying the concrete will not be permitted.
- C. Field Control: Concrete samples for slump, air content, and test cylinders shall be taken at the placement end of the hose.

3.05 ORDER OF PLACING CONCRETE

A. General

1. The order of placing concrete in the Work shall be acceptable to the Engineer.
 2. In order to minimize the effects of shrinkage, the concrete shall be placed in units as bounded by construction joints at the indicated locations.
- B. The placing of units shall be done by placing alternate units in a manner such that each unit placed shall have cured at least 2 Days for all structures before the contiguous unit or units are placed, except that the corner sections of vertical walls shall not be placed until the 2 adjacent wall panels have cured at least 4 Days for all structures.

C. Concrete Surfaces

1. The surface of the concrete shall be level whenever a run of concrete is stopped.
2. For a level, straight, intermediate joint on the exposed surface of walls, a wood strip at least 3/4-inch thick shall be tacked to the forms on these surfaces.
3. The concrete shall be carried approximately 1/2 inch above the underside of the strip.
4. The strip shall be removed one hour after the concrete is placed, and any irregularities in the edge formed by the strip shall be leveled with a trowel and laitance shall be removed.

3.06 TAMPING AND VIBRATING

A. As concrete is placed in the forms or in excavations, it shall be thoroughly settled and compacted throughout the entire depth of the layer, which is being consolidated, into a dense and homogeneous mass, filling all corners and angles, thoroughly embedding the reinforcement, eliminating rock pockets, and bringing only a slight excess of water to the exposed surface of concrete.

B. Vibrators

1. Vibrators shall be high speed power vibrators of an immersion type in sufficient number and with at least one standby unit as required.
2. Vibrators shall have the following characteristics and performance attributes:
 - a. Diameter of head: 2 to 3-1/2 inches;
 - b. Operating frequency in concrete: 8,000 to 12,000 vibrations per minute;
 - c. Eccentric moment: 0.20 to 0.70 in-lbs (calculated in accordance with ACI 309R-05 Fig. A.2 – Action of rotary vibrator);
 - d. Average amplitude operating in air (half of the peak-to-peak amplitude): 0.025 to 0.05 inches;
 - e. Centrifugal force using frequency of vibrator while operating in concrete: 700 to 2000 lbs (calculated in accordance with ACI 309R-05 Fig. A.2– Action of rotary vibrator);
 - f. Radius of influence: 7 to 14 inches.
3. Vibrators for plastic concrete in thin walls, columns, beams, thin slabs, along construction joints, and to supplement larger vibrators in confined areas shall have the following characteristics and performance attributes:
 - a. Diameter of head: 1-1/4 to 2-1/2 inches;
 - b. Operating frequency in concrete: 8,500 to 12,500 vibrations per minute;
 - c. Eccentric moment: 0.08 to 0.25 in-lbs (calculated in accordance with ACI 309R-05 Fig. A.2 – Action of rotary vibrator);
 - d. Average amplitude operating in air (half of the peak-to-peak amplitude): 0.02 to 0.04 inches;
 - e. Centrifugal force using frequency of vibrator while operating in concrete: 300 to 900 lbs (calculated in accordance with ACI 309R-05 Fig. A.2– Action of rotary vibrator);
 - f. Radius of influence: 5 to 10 inches.

C. Waterstops

1. Care shall be exercised when placing concrete around waterstops.

2. The concrete shall be carefully worked by rodding and vibrating to make sure that air and rock pockets have been eliminated.
3. Where flat-strip type waterstops have been placed horizontally, the concrete shall be worked under the waterstops by hand, making sure that air and rock pockets have been eliminated.
4. Concrete that is surrounding the waterstops shall be given additional vibration over and above that used for adjacent concrete placement to ensure complete embedment of the waterstops in the concrete.

D. Concrete in Walls

1. Concrete in walls shall be internally vibrated and at the same time rammed, stirred, or worked with suitable appliances, tamping bars, shovels, or forked tools until it completely fills the forms or excavations and closes snugly against each surface.
2. Subsequent layers of concrete shall not be placed until the layers previously placed have been worked thoroughly.
3. Vibrators shall be provided in sufficient numbers, with standby units as required, to accomplish the required results within 15 minutes after concrete of the prescribed consistency has been placed in the forms.
4. The vibrating head shall not contact the surfaces of the forms.
5. Care shall be exercised not to vibrate concrete excessively or to work it in any manner that causes segregation of its constituents.

3.07 FINISHING CONCRETE SURFACES

A. General

1. Surface defects are defined as fins, bulges, ridges, offsets, honeycombing, roughness of any kind, and surface holes larger than 1/2 inch in diameter or deeper than 1/4 inch.
2. Concrete surfaces shall be free from surface defects and shall present a finished, smooth, continuous hard surface.
3. Allowable deviations from plumb or level and from the alignment, profiles, and dimensions are defined as tolerances and shall be as indicated.
4. These tolerances are to be distinguished from irregularities in finish as indicated.
5. Aluminum finishing tools shall not be used.

B. Formed Surfaces

1. Formed surfaces shall be treated to provide a "Smooth Form Finish", which consists of finishing the surfaces as necessary to produce smooth, even surfaces of uniform texture and appearance, free of surface defects, depressions and other imperfections.
2. Form tie holes and defective concrete shall be repaired.

C. Unformed Surfaces

1. General

- a. After proper and adequate vibration and tamping, unformed top surfaces of slabs, floors, walls, and curbs shall be brought to a uniform surface with suitable tools.

2. The classes of finish for unformed concrete surfaces are defined as follows:

a. Finish U1

- 1) Sufficient leveling and screeding to produce an even, uniform surface with surface irregularities not to exceed 3/8 inch.
- 2) No further special finish is required.

b. Finish U2

- 1) After sufficient stiffening of the screeded concrete, surfaces shall be float finished with wood or metal floats or with a finishing machine using float blades.
- 2) Excessive floating of surfaces while the concrete is plastic and dusting of dry cement and sand on the concrete surface to absorb excess moisture will not be permitted.
- 3) Floating shall be the minimum necessary to produce a surface that is free from screed marks and is uniform in texture.
- 4) Surface irregularities shall not exceed 1/4 inch.
- 5) Joints and edges shall be tooled where indicated or as determined by the Engineer.

c. Finish U3

- 1) After the Finish U2 surface has hardened sufficiently to prevent excess of fine material from being drawn to the surface, steel troweling shall be performed with firm pressure such as will flatten the sandy texture of the floated surface and produce a dense, uniform surface free from blemishes, ripples, and trowel marks.
- 2) The finish shall be smooth and free of irregularities.

d. Finish U4

- 1) Trowel the Finish U3 surface to remove local depressions or high points.
- 2) In addition, the surface shall be given a light broom finish with brooming perpendicular to drainage unless otherwise indicated.
- 3) The resulting surface shall be sufficiently rough to provide a nonskid finish.

- e. Unformed surfaces shall be finished according to the following schedule:

CAST-IN-PLACE CONCRETE

UNFORMED SURFACE FINISH SCHEDULE	
Area	FINISH
grade slabs and foundations to be covered with concrete or fill material	U1
floors to be covered with grouted tile or topping grout	U2
slabs not water bearing	U4
slabs to be covered with built-up roofing	U2
top surface of walls	U3

3.08 CURING AND DAMPPROOFING

- A. General: Concrete shall be cured for not less than 7 Days after placement, in accordance with the methods indicated below for the different parts of the Work.

Surface to be Cured or Dampproofed	Method
unstripped forms	1
construction joints between footings and walls, and between floor slab and columns	2
encasement and ductbank concrete and thrust blocks	3
concrete surfaces not specifically indicated in this Paragraph	4
floor slabs on grade	5
slabs not on grade	6
wall sections with forms removed	6

B. Method 1

1. Wooden forms shall be wetted immediately after concrete has been placed and shall be kept wet with water until removal.
2. If steel forms are used the exposed concrete surfaces shall be kept continuously wet until the forms are removed.
3. If forms are removed within 7 Days of placing the concrete, curing shall be continued in accordance with Method 6, below.

C. Method 2

1. The surface shall be covered with burlap mats which shall be kept wet with water for the duration of the curing period, until the concrete in the walls has been placed.
2. No curing compound shall be applied to surfaces cured under Method 2.

D. Method 3

1. The surface shall be covered with moist earth not less than 4 hours nor more than 24 hours after the concrete is placed.

2. Earthwork operations that may damage the concrete shall not begin until at least 7 Days after placement of the concrete.

E. Method 4

1. The surface shall be sprayed with a liquid curing compound.
2. The compound shall be applied in accordance with the manufacturer's printed instructions at a maximum coverage rate of 200 square feet per gallon and in such a manner as to cover the surface with a uniform film that will seal thoroughly.
3. Seal Protection
 - a. Where the curing compound method is used, care shall be exercised to avoid damage to the seal during the 7-Day curing period.
 - b. If the seal is damaged or broken before expiration of the curing period, the break shall be repaired immediately by the application of additional curing compound over the damaged portion.
4. Wherever curing compound has been applied by mistake to surfaces against which concrete subsequently is to be placed and to which it is to adhere, such compound shall be entirely removed by wet sandblasting just prior to the placing of new concrete.
5. Application Schedule
 - a. The curing compound shall be applied as soon as the concrete has hardened enough to prevent marring on unformed surfaces and within 2 hours after removal of forms.
 - b. Repairs to formed surfaces shall be made within the 2 hour period; provided, however, that any such repairs which cannot be made within the said 2 hour period shall be delayed until after the curing compound has been applied.
 - c. When repairs are to be made to an area on which curing compound has been applied, the area involved shall first be wet-sandblasted to remove the curing compound.
6. At locations where concrete is placed adjacent to a panel which has been coated with curing compound, the panel shall have curing compound reapplied to an area within 6 feet of the joint and to any other location where the curing membrane has been disturbed.
7. Prior to final acceptance of the Work, visible traces of curing compound shall be removed in such a manner that does not damage the surface finish.

F. Method 5

1. Until the concrete surface is covered with curing compound, the entire surface shall be kept damp by applying water using nozzles that atomize the flow such that the surface is not marred or washed.
2. The concrete shall be given a coat of curing compound in accordance with Method 4, above.

3. Not less than one hour nor more than 4 hours after the curing compound has been applied, the surface shall be wetted with water delivered through a fog nozzle, and concrete-curing blankets shall be placed on the slabs.
4. Curing Blankets
 - a. The curing blankets shall be laid with the edges butted together and with the joints between strips sealed with 2-inch wide strips of sealing tape or with edges lapped not less than 3 inches, and fastened together with a waterproof cement to form a continuous watertight joint.
 - b. The curing blankets shall be left in place during the 7-Day curing period and shall not be removed until after concrete for adjacent Work has been placed.
 - c. If the curing blankets become torn or otherwise ineffective, the Contractor shall replace damaged sections.
 - d. During the first 3 Days of the curing period, no traffic of any nature and no depositing, temporary or otherwise, of any materials will be permitted on the curing blankets.
 - e. During the remainder of the curing period, foot traffic and temporary depositing of materials that impose light pressure will be permitted only on top of plywood sheets 5/8-inch minimum thickness, laid over the curing blanket.
 - f. The Contractor shall add water under the curing blanket as often as necessary to maintain damp concrete surfaces.

G. Method 6

1. Method 6 shall apply to both walls and slabs.
2. The concrete shall be kept continuously wet by the application of water for a minimum period of at least 7 Days, beginning immediately after the concrete has reached final set or the forms have been removed.
3. Until the concrete surface is covered with the curing mats, the entire surface shall be kept damp by applying water using nozzles that atomize the flow such that the surface is not marred or washed.
4. Curing Mats
 - a. Heavy curing mats shall be used as a curing medium to retain the moisture during the curing period.
 - b. The curing mats shall be weighted or otherwise held substantially in contact with the concrete surface to prevent dislodging by wind or other causes.
 - c. Edges shall be continuously held in place.
5. The curing mats and concrete shall be kept continuously wet by the use of sprinklers or other means both during and after normal working hours.

6. Immediately after the application of water has terminated at the end of the curing period, the curing mats shall be removed, the entire concrete surface shall be wetted, and curing compound shall be immediately applied to the entire surface in accordance with Method 4, above.
7. The Contractor shall dispose of excess water from the curing operation in order to avoid damage to the Work.

H. Dampproofing

1. The exterior surfaces of roof slabs to be buried and walls to be backfilled shall be dampproofed as follows.
2. Asphalt Emulsion
 - a. Immediately after the completion of curing, the surface shall be sprayed with a dampproofing agent consisting of an asphalt emulsion.
 - b. Application of the agent shall be in 2 coats.
 - c. The first coat shall be diluted to 1/2 strength by the addition of water and shall be sprayed on so as to provide a maximum coverage rate of 100 square feet per gallon of dilute solution.
 - d. The second coat shall consist of an application of the undiluted material and shall be sprayed on so as to provide a maximum coverage rate of 100 square feet per gallon.
3. Whitewash
 - a. As soon as the material has taken an initial set, the entire area thus coated shall be coated with whitewash.
 - b. Any formula for mixing the whitewash may be used if it produces a uniformly-coated white surface and remains until placing of the backfill.
 - c. If the whitewash fails to remain on the surface until the backfill is placed, the Contractor shall apply additional whitewash.

3.09 PROTECTION

- A. The Contractor shall protect the concrete against damage until final acceptance.
- B. Weather Protection
 1. Fresh concrete shall be protected from damage due to rain, hail, sleet or snow.
 2. The Contractor shall provide such protection while the concrete is still plastic and whenever precipitation is imminent or occurring.

3.10 CURING DURING COLD WEATHER

- A. Water curing of concrete may be reduced to 6 Days during periods when the mean daily temperature in the vicinity of the Site is less than 40 degrees F, provided that during the prescribed period of water curing, when temperatures are such that concrete surfaces may freeze, water curing has been temporarily discontinued.
- B. Compound-Cured Concrete
 - 1. Concrete that is to be cured by an application of curing compound shall require no additional protection from freezing if the protection at 50 degrees F for 72 hours is obtained by means of approved insulation in contact with the forms or concrete surfaces.
 - 2. Otherwise, the concrete shall be protected against freezing temperatures for 72 hours immediately following 72 hours protection at 50 degrees F.
- C. Concrete cured by water shall be protected against freezing temperatures for 72 hours immediately following the 72 hours of protection at 50 degrees F.
- D. Discontinuance of Protection
 - 1. Discontinuance of protection against freezing temperatures shall be such that the drop in temperature of any portion of the concrete will be gradual and will not exceed 40 degrees F in 24 hours.
 - 2. In the spring, when the mean daily temperature rises above 40 degrees F for more than 3 successive Days, the required 72-hour protection at a temperature not lower than 50 degrees F may be discontinued for as long as the mean daily temperature remains above 40 degrees F, provided that the concrete shall be protected against freezing temperatures for not less than 48 hours after placement.
- E. Artificial Heat
 - 1. Where artificial heat is employed, special care shall be taken to prevent the concrete from drying.
 - 2. The use of unvented heaters will be permitted only when unformed surfaces of concrete adjacent to the heaters are protected for the first 24 hours from an excessive carbon dioxide atmosphere by application of curing compound, provided that the use of curing compound for such surfaces is otherwise permitted.

3.11 TREATMENT OF SURFACE DEFECTS

- A. General
 - 1. Surface defects are defined in Finishing Concrete Surfaces, above.
 - 2. As soon as forms are removed, the exposed concrete surfaces shall be carefully examined and any irregularities shall be immediately rubbed or ground in order to secure a smooth, uniform, and continuous surface satisfactory to the Engineer.
 - 3. Plastering or coating of surfaces to be smoothed will not be permitted.
 - 4. No repairs shall be made until after inspection by the Engineer.

5. In no case will extensive patching of honeycombed concrete be permitted.
6. Concrete containing minor voids, holes, honeycombing, or similar depression defects shall be repaired as indicated below.
7. Concrete containing extensive voids, holes, honeycombing, or similar depression defects shall be completely removed and replaced.
8. Repairs of surface defects shall be performed promptly.

B. Preparation

1. Defective surfaces to be repaired shall be cut back from trueline a minimum depth of 1/2-inch over the entire area.
2. Feathered edges will not be permitted.
3. Where chipping or cutting tools are not required in order to deepen the area properly, the surface shall be prepared for bonding by the removal of laitance and soft material, plus not less than 1/32-inch depth of the surface film from hard portions by means of an efficient sandblast.
4. After cutting and sandblasting, the surface shall be wetted sufficiently in advance of shooting with shotcrete or with cement mortar such that while the repair material is being applied the surfaces underneath will remain moist but not so wet as to overcome the suction upon which a good bond depends.

C. Materials

1. The material used for repair shall consist of a mixture of one sack of cement to 3 cubic feet of sand.
2. For exposed walls, the cement shall contain such a proportion of Atlas White Portland cement as is required to make the color of the patch match the color of the surrounding concrete.

D. Holes

1. Holes left by tie-rod cones shall be reamed with suitably toothed reamers in order to leave the surfaces of the holes clean and rough.
2. Holes then shall be repaired in an approved manner with dry-packed cement grout.
3. Holes left by form-tying devices having a rectangular cross section and other imperfections having a depth greater than their least surface dimension shall not be reamed but shall be repaired in an approved manner with dry-packed cement grout.

E. Repairs

1. Repairs shall be built up and shaped in such a manner that the completed Work will conform to the indicated requirements, using approved methods which will not disturb the bond, cause sagging, or cause horizontal fractures.

2. The surfaces of repaired concrete shall receive the same kind and amount of curing treatment as required for the concrete in the repaired section.
- F. Cracks: Prior to filling any structure with water, cracks shall be repaired in accordance with the requirements of Section 03 01 00 – Maintenance of Concrete.

3.12 CONCRETE REPAIR AND REHABILITATION

- A. All defects and repairs not covered under Treatment of Surface Defects shall be repaired per Section 03 01 00 - Maintenance of Concrete.

3.13 CARE AND REPAIR OF CONCRETE

- A. The Contractor shall protect concrete against injury or damage from excessive heat, lack of moisture, overstress, or any other cause until Final Acceptance.
- B. Particular care shall be exercised in order to prevent the drying shrinkage damage of concrete and to avoid roughening or otherwise damaging the concrete surface.
- C. Any concrete found to be damaged, or which may have been originally defective, or which becomes defective at any time prior to the final acceptance of the completed Work, or which departs from the established line or grade, or which, for any other reason, does not conform to the requirements of the Contract Documents, shall be repaired or removed and replaced with acceptable materials to the satisfaction of the Engineer.

END OF SECTION

SECTION 03 41 13 – PRECAST CONCRETE HOLLOW CORE PLANKS

PART 1 -- GENERAL

1.01 SUMMARY

- A. This Section includes the performance criteria, materials, design, production, and erection of structural precast and precast, prestressed concrete for the entire project. The work performed under this Section includes all labor, material, equipment, related services, and supervision required for the manufacture and erection of the structural precast and precast, prestressed concrete work shown on the Contract Drawings.
- B. This Section includes the following:
 - 1. Hollow-core slab units.
- C. Providing openings in precast concrete plank units to accommodate the Work under this and other Sections and building into precast concrete plank units items such as sleeves, anchor systems, and inserts.

1.02 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

A. Referenced Specifications

01 33 00	Submittal Procedures
03 60 00	Grouting

- B. References herein to "Building Code" shall mean the 2024 Ohio Building Code (OBC). The edition of the standards applicable to the Work shall be those editions referenced by the OBC. If the standard is not referenced by the OBC, nor an IBC-referenced standard listed below, the edition of the standard applicable to the Work shall be the edition in effect on the date of award of this contract.

American Concrete Institute	
ACI 318	Building Code Requirements for Structural Concrete and Commentary
ACI PRC-211.1	Selecting Proportions for Normal-Density and High Density-Concrete
ASTM International (ASTM)	
ASTM A36	Carbon Structural Steel
ASTM A184	Welded Deformed Steel Bar Mats for Concrete Reinforcement
ASTM A307	Carbon Steel Bolts, Studs, and Threaded Rod 60,000 PSI Tensile Strength
ASTM A416	Low-Relaxation, Seven-Wire Steel Strand for Prestressed Concrete
ASTM A563	Carbon and Alloy Steel Nuts (Inch and Metric)
ASTM A615	Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement
ASTM A706	Deformed and Plain Low-Alloy Steel Bars for Concrete Reinforcement
ASTM A886	Steel Strand, Indented, Seven-Wire Stress-Relieved for Prestressed Concrete
ASTM A910	Uncoated, Weldless, 2-Wire and 3-Wire Steel Strand for Prestressed

	Concrete
ASTM A1064	Steel Welded Wire Reinforcement, Plain, for Concrete
ASTM C33	Concrete Aggregates
ASTM C42	Obtaining and Testing Drilled Cores and Sawed Beams of Concrete
ASTM C144	Aggregate for Masonry Mortar
ASTM C150	Portland Cement
ASTM C404	Aggregate for Masonry Grout
ASTM C494	Chemical Admixtures for Concrete
ASTM C595	Blended Hydraulic Cement
ASTM C618	Coal Ash and Raw or Calcined Natural Pozzolan for Use in Concrete
ASTM C1218	Water-Soluble Chloride in Mortar and Concrete
ASTM C1240	Silica Fume Used in Cementitious Mixtures
ASTM C1610	Static Segregation of Self-Consolidating Concrete Using Column Technique
ASTM C1611	Slump Flow of Self-Consolidating Concrete
ASTM C1621	Passing Ability of Self-Consolidating Concrete
ASTM C1712	Rapid Assessment of Static Segregation Resistance of Self-Consolidating Concrete Using Penetration Test
ASTM D412	Vulcanized Rubber and Thermoplastic Elastomers - Tension
ASTM D2240	Rubber Property – Durometer Hardness
ASTM E165	Magnesium Oxide and Aluminum Oxide Powder and Crushable Insulators Used in the Manufacture of Base Metal Thermocouples, Metal-Sheathed Platinum Resistance Thermometers, and Noble Metal Thermocouples
ASTM E543	Agencies Performing Nondestructive Testing
ASTM F844	Washers, Steel, Plain (Flat), Unhardened for General Use
ASTM F3125	High Strength Structural Bolts and Assemblies, Steel and Alloy Steel, Heat Treated, Inch Dimensions 120 ksi and 150 ksi Minimum Tensile Strength
American Welding Society (AWS)	
AWS C5.4	Recommended Practices for Stud Welding
AWS D1.1	Structural Welding Code – Steel
AWS D1.4	Structural Welding Code – Reinforcement Steel
AWS D1.6	Structural Welding Code - Stainless
AWS QC1	Qualification and Certification of Welding Inspectors
Precast Concrete Institute	
PCI MNL 116	Manual for Quality Control for Plants and Production of Structural Concrete Products
PCI MNL 120	PCI Design Handbook, Precast and Prestressed Concrete
PCI MNL 124	Design for Fire Resistance of Precast Prestressed Concrete
PCI MNL 135	Tolerance Manual for Precast and Prestressed Concrete Construction

PCI TR-6	Interim Guidelines for the Use of Self-Consolidating Concrete
International Code Council (ICC)	
OBC	2024 Ohio Building Code

1.03 PERFORMANCE REQUIREMENTS

- A. Structural Performance: Provide structural precast concrete members and connections capable of withstanding design loads indicated within limits and under conditions indicated on the Contract Drawings.

1.04 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated. Retain quality control records and certificates of compliance for 5 years after completion of structure.
- B. Design Mixtures: For each precast concrete mixture. Include compressive strength.
- C. Shop (Erection) Drawings:
 - 1. Detail fabrication and installation of structural precast concrete units including connections at member ends and to each adjoining member.
 - 2. Indicate locations, plan views, elevations, dimensions, shapes, and cross sections of each unit, openings, support conditions and types of reinforcement, including special reinforcement.
 - 3. Indicate aesthetic intent including joints, rustications or reveals, and extent and location of each surface finish.
 - 4. Indicate welded connections by AWS standard symbols. Show size, length, and type of each weld.
 - 5. Detail loose and cast-in hardware, lifting and erection inserts, connections, and joints.
 - 6. Indicate locations, tolerances and details of anchorage devices to be embedded in or attached to structure or other construction.
 - 7. Include and locate openings larger than 10 in. Where additional structural support is required for openings include header design.
 - 8. Coordinate and indicate openings and inserts required by other trades.
 - 9. Indicate location of each structural precast concrete member by same identification mark placed on unit.
 - 10. Indicate relationship of structural precast concrete members to adjacent materials.
 - 11. Indicate locations and details of joint treatment.
 - 12. Indicate areas receiving toppings and magnitude of topping thickness.
 - 13. Indicate estimated cambers for floor slabs receiving cast-in-place topping.

14. Indicate shim sizes and grouting sequence.
 15. Design Modifications: If design modifications are proposed to meet performance requirements and field conditions, notify the Engineer and submit design calculations and Shop Drawings. Do not affect the appearance, durability or strength of members when modifying details or materials. Maintain the general design concept when altering size of members and alignment.
- D. Provide handling procedures, erection sequences, and for special conditions provide temporary bracing and shoring plan.
- E. Delegated Design Submittal:
1. Complete design computations of each precast concrete hollow plank unit, including the axial forces and diaphragm forces due to lateral loads and of the connections. Computations shall be signed and sealed by professional engineer. Professional engineer's seal shall be clearly legible, including jurisdiction of registration, registration number, and name on seal.
 2. Certification by professional engineer that design of precast concrete hollow plank units was performed in accordance with performance and design criteria stated in the Contract Documents, and that design complies with Laws and Regulations and prevailing standards of practice.

1.05 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For erector, fabricator and testing agency and persons specified in Quality Assurance to demonstrate their capabilities and experience. Include list of completed projects with project names and addresses, names and addresses of engineers and owners, and other information specified.
- B. Welding Certificates: Copies of certificates for welding procedure specifications (WPS) and personnel certification.
- C. Material Test Reports for aggregates: From an accredited testing agency, indicating and interpreting test results for compliance with requirements indicated.
- D. Material Certificates: Signed by manufacturers certifying that each of the following items complies with requirements.
1. Cementitious materials.
 2. Reinforcing materials and prestressing tendons.
 3. Admixtures.
 4. Bearing pads.
 5. Structural-steel shapes and hollow structural sections.
 6. Other components specified in Contract Documents with applicable standards.
- E. Field quality-control test and special inspections reports.

1.06 QUALITY ASSURANCE

- A. Erector Qualifications: A precast concrete erector who has retained a PCI Certified Field Auditor, at erector's expense, to conduct a field audit of a project in the same category as this Project prior to start of erection. Submits Erectors' Post Audit Declaration.
- B. Fabricator Qualifications: A firm that complies with the following requirements and is experienced in producing structural precast concrete units for not less than 5 years similar to those indicated for this Project and with a record of successful in-service performance.
 - 1. Participates in PCI's Plant Certification program at the time of bidding and is designated a PCI-certified plant for Group C, Category C2 – Prestressed Hollow-Core and Repetitive Products.
 - 2. Has sufficient production capacity to produce required members without delaying the Work.
 - 3. Certification shall be maintained throughout the production of the precast concrete units. Production shall immediately stop if at any time the fabricator's certification is revoked, regardless of the status of completion of contracted work. Production will not be allowed to re-start until the necessary corrections are made and certification has been re-established. In the event certification(s) cannot be re-established in a timely manner, causing project delays, the fabricator, at no additional cost, will contract out the remainder of the units to be manufactured at a PCI certified plant.
- C. Professional Engineer
 - 1. Contractor or precast concrete hollow plank units manufacturer shall retain a registered professional engineer legally qualified to practice in the jurisdiction where the Site is located. Professional engineer shall have not less than 5 years' experience designing precast concrete hollow plank units.
 - 2. Responsibilities shall include:
 - a. Reviewing precast concrete hollow plank units performance and design criteria shown and indicated in the Contract Documents.
 - b. Preparing written requests for clarifications or interpretations of performance or design criteria for submittal to Engineer by Contractor.
 - c. Preparing or supervising preparation of design calculations verifying compliance of precast concrete hollow plank units with requirements of the Contract Documents.
 - d. Signing and sealing all calculations.
 - e. Certifying that:
 - 1) Design of precast prestressed hollow plank units was performed in accordance with performance and design criteria shown and indicated in the Contract Documents, and

- 2) Design complies with Laws and Regulations, and prevailing standards of practice.
 - D. Design Standards: Comply with ACI 318 and the design recommendations of PCI MNL 120, "PCI Design Handbook – Precast and Prestressed Concrete," applicable to types of structural precast concrete members indicated.
 - E. Quality-Control Standard: For manufacturing procedures and testing requirements and quality control recommendations for types of members required, comply with PCI MNL 116, "Manual for Quality Control for Plants and Production of Structural Concrete Products."
 - 1. Comply with camber and dimensional tolerances of PCI MNL 135, "Tolerance Manual for Precast and Prestressed Concrete Construction."
 - F. Welding: Qualify procedures and personnel according to AWS D1.1, "Structural Welding Code – Steel"; AWS D1.4/D1.4M, "Structural Welding Code – Reinforcing Steel"; and AWS D1.6, "Structural Welding Code-Stainless".
 - G. Fire Resistance: Where indicated, provide structural precast concrete members whose fire resistance satisfy the fire resistance ratings of the Contract Documents and meets the prescriptive requirements of the governing code or has been calculated according to PCI MNL 124, "Design for Fire Resistance of Precast Prestressed Concrete," and is acceptable to authorities having jurisdiction.
- 1.07 DELIVERY, STORAGE, AND HANDLING
- A. Deliver all structural precast concrete members in such quantities and at such times to assure compliance with the agreed upon project schedule and setting sequence to ensure continuity of installation.
 - B. Handle and transport members in a manner to avoid excessive stresses that could cause cracking or other damage.
 - C. Store units with adequate dunnage and bracing, and protect units to prevent contact with soil, staining, and to control cracking, distortion, warping or other physical damage.
 - D. Unless otherwise specified or shown on Shop Drawings, store members with dunnage across full width of each bearing point.
 - E. Place stored members so identification marks are clearly visible, and units can be inspected.
 - F. Place dunnage of even thickness between each member.
 - G. Lift and support members only at designated points indicated on the Shop Drawings.
- 1.08 SEQUENCING
- A. Furnish loose connection hardware and anchorage items to be embedded in or attached to other construction without delaying the Work. Provide locations, setting diagrams, templates, instructions, and directions, as required, for installation.

PART 2 -- PRODUCTS

2.01 FABRICATORS

- A. Fabricators: Subject to compliance with requirements, provide products by one of the following:
 - 1. DBS Prestress of Ohio, Huber Heights, Ohio 937-878-8232.
<http://www.deamron.com>
 - 2. Mack Industries, Inc., Valley City, Ohio 330-460-7005.
<http://www.mackconcrete.com>
 - 3. Or Equal

2.02 FORM MATERIALS

- A. Forms: Rigid, dimensionally stable, nonabsorptive material, warp and buckle free, that will provide precast concrete surfaces within fabrication tolerances indicated; nonreactive with concrete and suitable for producing required surface finishes.
 - 1. Form-Release Agent: Commercially produced form-release agent that will not bond with, stain or affect hardening of precast concrete surfaces and will not impair subsequent surface or joint treatments of precast concrete.

2.03 REINFORCING MATERIALS

- A. Reinforcing Bars: ASTM A615, Grade 60, deformed.
- B. Low-Alloy-Steel Reinforcing Bars: ASTM A706, deformed for reinforcing steel required to be welded.
- C. Steel Bar Mats: ASTM A184, fabricated from ASTM A615, Grade 60, deformed bars, assembled with clips.
- D. Plain-Steel Welded Wire Reinforcement: ASTM A1064, fabricated from as-drawn steel wire into flat sheets.
- E. Deformed-Steel Welded Wire Reinforcement: ASTM A1064, flat sheet.
- F. Supports: Use bolsters, chairs, spacers, and other devices for spacing, supporting, and fastening reinforcing bars and welded wire reinforcement in place according to PCI MNL 116.

2.04 PRESTRESSING TENDONS

- A. Prestressing Strand: ASTM A416, Grade 250 or Grade 270, uncoated, 7-wire, low-relaxation strand or ASTM A886, Grade 270, indented, 7-wire, low-relaxation strand (including supplement).
- B. Prestressing Strand: ASTM A910, Grade 270, uncoated, weldless, 2-and 3-wire, low relaxation strand.

2.05 CONCRETE MATERIALS

- A. Portland Cement: ASTM C150, Type I or III or Blended Hydraulic Cement: ASTM C595 Type IL.
 - 1. For surfaces exposed to view in finished structure, use same type, brand, and mill source throughout the precast concrete production.
- B. Supplementary Cementitious Materials
 - 1. Fly Ash: ASTM C618, Class C or F with maximum loss on ignition of 3%.
 - 2. Silica Fume: ASTM C1240 with optional chemical and physical requirements.
- C. Normal weight Aggregates: Except as modified by PCI MNL 116, ASTM C33, with coarse, non-reactive aggregates complying with Class 2M. Stockpile fine and coarse aggregates for each type of exposed finish from a single source (pit or quarry) for Project.
- D. Water: Potable; free from deleterious material that may affect color stability, setting, or strength of concrete and complying with chemical limits of PCI MNL 116.
- E. Chemical Admixtures: Certified by manufacturer to be compatible with other admixtures and to not contain calcium chloride, or more than 0.15 percent chloride ions or other salts by weight of admixture.
 - 1. Water-Reducing Admixture: ASTM C494, Type A.
 - 2. Water-Reducing and Accelerating Admixture ASTM C494, Type E.
 - 3. High Range, Water-Reducing Admixture: ASTM C494, Type F.

2.06 STEEL CONNECTION MATERIALS

- A. Carbon-Steel Shapes and Plates: ASTM A36
- B. Carbon-Steel Headed Studs: ASTM A108, Grades 1010 through 1020, cold finished, AWS D1.1, Type A or B, with arc shields and with the minimum mechanical properties of PCI MNL 116, Table 3.2.3.
- C. Carbon-Steel Bolts and Studs: ASTM A307, Grade A or C carbon-steel, hex-head bolts and studs; carbon-steel nuts (ASTM A563, Grade A); and flat, unhardened steel washers (ASTM F844).
- D. Shop-Primed Finish: Prepare surfaces of nongalvanized steel items, except those surfaces to be embedded in concrete, according to requirements in SSPC-SP 3 and shop-apply lead- and chromate-free, rust –inhibitive primer, complying with performance requirements in MPI 79 according to SSPC-PA 1.

2.07 BEARING PADS AND OTHER ACCESSORIES

- A. Provide one of the following bearing pads for structural precast concrete members as recommended by precast fabricator for application:

1. Elastomeric Pads: AASHTO M 251, plain, vulcanized, 100 percent polychloroprene (neoprene) elastomer, molded to size or cut from a molded sheet, 50 to 70 Shore A durometer according to ASTM D2240, minimum tensile strength 2250 psi per ASTM D412.
 2. Random-Oriented, Fiber-Reinforced Elastomeric Pads: Preformed, randomly oriented synthetic fibers set in elastomer. Surface hardness of 70 to 90 Shore A durometer according to ASTM D2240. Capable of supporting a compressive stress of 3000 psi with no cracking, splitting or delaminating in the internal portions of the pad.
- B. Erection Accessories: Provide clips, hangers, high density plastic or steel shims, and other accessories required to install structural precast concrete members.
- C. Welding Electrodes: Comply with AWS standards for steel type and/or alloy being welded.

2.08 GROUT MATERIALS

- A. Sand-Cement Grout: Portland cement, ASTM C150, Type I, and clean, natural sand, ASTM C144, or ASTM C404. Mix at ratio of 1 part cement to 2 ½ to 3 parts sand, by volume, with minimum water required for placement and hydration. Water-soluble chloride ion content of grout less than 0.06 percent chloride ion by weight of cement when tested in accordance with ASTM C1218.

2.09 CONCRETE MIXTURES

- A. Prepare design mixtures for each type of precast concrete required.
1. Limit use of fly ash to 35 percent replacement of portland cement by weight; and silica fume to 10 percent of portland cement by weight.
- B. Design mixtures may be prepared by a qualified independent testing agency or by qualified precast plant personnel at structural precast concrete fabricator's option.
- C. Limit water-soluble chloride ions to maximum percentage by weight of cement permitted by ACI 318 or PCI MNL 116 when tested in accordance with ASTM C 1218.
- D. Normal weight Concrete Mixtures: Proportion mixtures by either laboratory trial batch or field test data methods according to ACI 211.1, with materials to be used on Project, to provide normal weight concrete with the following properties:
1. Compressive Strength (28 Days): 5000 psi minimum.
 2. Release Strength: as required by design.
 3. Maximum Water-Cementitious Materials Ratio: 0.44.
- E. Add air-entraining admixture at manufacturer's prescribed rate to result in concrete at point of placement having an air content complying with PCI MNL 116.
- F. When included in design mixtures, add other admixtures to concrete mixtures according to manufacturer's written instructions.

- G. Concrete Mixture Adjustments: Concrete mixture design adjustments may be proposed if characteristics of materials, Project conditions, weather, test results, or other circumstances warrant.

2.010 FORM FABRICATION

- A. Form: Accurately construct forms, mortar tight, of sufficient strength to withstand pressures due to concrete placement and vibration operations and temperature changes, and for prestressing and detensioning operations. Coat contact surfaces of forms with release agent before reinforcement is placed. Avoid contamination of reinforcement and prestressing tendons by release agent.
- B. Maintain forms to provide completed structural precast concrete members of shapes, lines, and dimensions indicated in Contract Documents, within fabrication tolerances specified.
 - 1. Edge and Corner Treatment: Uniformly radiused or as built-in on standard forms.

2.011 FABRICATION

- A. Cast-in Anchors, Inserts, Plates, Angles, and Other Anchorage Hardware: Fabricate anchorage hardware with sufficient anchorage and embedment to comply with design requirements. Accurately position for attachment of loose hardware and secure in place during precasting operations. Locate anchorage hardware where it does not affect position of main reinforcement or concrete placement. Do not relocate bearing plates in members unless approved by Engineer.
 - 1. Weld headed studs and deformed bar anchors used for anchorage according to AWS D1.1 and AWS C5.4, "Recommended Practices for Stud Welding."
- B. Furnish loose hardware items including steel plates, clip angles, seat angles, anchors, dowels, hangers, and other hardware shapes for securing precast concrete members to supporting and adjacent construction.
- C. Cast-in reglets, slots, and other accessories in structural precast concrete members as indicated on Contract Drawings.
- D. Cast-in openings larger than 10 inches in any dimension. Do not drill or cut openings or prestressing strand without Engineer's approval.
- E. Reinforcement: Comply with recommendations in PCI MNL 116 for fabricating, placing, and supporting reinforcement.
 - 1. Clean reinforcement of loose rust and mill scale, earth, and other materials that reduce or destroy the bond with concrete.
 - 2. Accurately position, support, and secure reinforcement against displacement during concrete-placement and consolidation operations. Locate and support reinforcement by plastic tipped or corrosion resistant metal or plastic chairs, runners, bolsters, spacers, hangers, and other devices for spacing, supporting, and fastening reinforcing bars and welded wire reinforcement in place according to PCI MNL 116.

3. Place reinforcing steel and prestressing tendons to maintain at least $\frac{3}{4}$ in. minimum concrete cover. Provide cover requirements in accordance with ACI 318 when units are exposed to corrosive environment or severe exposure conditions. Arrange, space, and securely tie bars and bar supports to hold reinforcement in position while placing concrete. Direct wire tie ends away from finished, exposed concrete surfaces.
 4. Install welded wire reinforcement in lengths as long as practicable. Lap adjoining pieces in accordance with ACI 318 and wire tie laps, where required by design. Offset laps of adjoining widths to prevent continuous laps in either direction.
- F. Reinforce structural precast concrete members to resist handling, transportation, and erection stresses, and specified in-place loads, whichever governs.
- G. Prestress tendons for structural precast concrete members by either pretensioning or post-tensioning methods. Comply with PCI MNL 116.
1. Delay detensioning or post-tensioning of precast prestressed concrete members until concrete has reached its indicated minimum design release compressive strength as established by test cylinders cured under the same conditions as concrete member.
 2. Detension pretensioned tendons either by gradually releasing tensioning jacks or by heat-cutting tendons, using a sequence and pattern to prevent shock or unbalanced loading.
 3. If concrete has been heat cured, detension while concrete is still warm and moist to avoid dimensional changes that may cause cracking or undesirable stresses.
 4. Protect strand ends and anchorage not exposed to view with bitumastic, zinc-rich or epoxy paint.
- H. Comply with requirements in PCI MNL 116 and in this Section for measuring, mixing, transporting, and placing concrete. After concrete batching, no additional water may be added.
- I. Place concrete in a continuous operation to prevent cold joints or planes of weakness from forming in precast concrete members.
1. Place backup concrete to ensure bond with face-mixture concrete.
- J. Thoroughly consolidate placed concrete by vibration without dislocating or damaging reinforcement and built-in items, and minimize pour lines, honeycombing or entrapped air voids on surfaces. Use equipment and procedures complying with PCI MNL 116.
1. Place self-consolidating concrete without vibration in accordance with PCI TR-6 "Interim Guidelines for the Use of Self-Consolidating Concrete." If face and backup concrete is used, ensure adequate bond between concrete mixtures.
- K. Comply with PCI MNL 116 procedures for hot and cold-weather concrete placement.
- L. Identify pickup points of precast concrete members and orientation in structure with permanent markings, complying with markings indicated on Shop Drawings. Imprint or

permanently mark casting date on each precast concrete member on a surface that will not show in finished structure.

- M. Cure concrete, according to requirements in PCI MNL 116, by moisture retention without heat or by accelerated heat curing using live steam or radiant heat and moisture. Cure members until compressive strength is high enough to ensure that stripping does not have an effect on the performance or appearance of final product.

2.012 FABRICATION TOLERANCES

- A. Fabricate structural precast concrete members of shapes, lines and dimensions indicated, so each finished member complies with PCI MNL 135 product tolerances as well as position tolerances for cast-in items.

2.013 FINISHES

A. Commercial (Structural) Finishes

- 1. Standard Grade: Normal plant-run finish produced in forms that impart a smooth finish to concrete. Surface holes smaller than 1/2 inch caused by air bubbles, normal color variations, form joint marks, and minor chips and spalls are acceptable. Fill air holes greater than 1/4 inch in width that occur in high concentration (more than one per 2 in.²). Major or unsightly imperfections, honeycombs, or structural defects are not permitted. Allowable joint offset limited to 1/8 inch.
- B. Apply roughened surface finish in accordance with ACI 318 to precast concrete members that will receive concrete topping after installation.

2.014 SOURCE QUALITY CONTROL

- A. Quality-Control Testing: Test and inspect precast concrete according to PCI MNL 116 requirements. If using self-consolidating concrete also test and inspect according to PCI TR-6 "Interim Guidelines for the Use of Self-Consolidating Concrete" and ASTM C 1611, ASTM C 1712, ASTM 1610, and ASTM C 1621.
- B. Strength of precast concrete members will be considered deficient if units fail to comply with ACI 318 concrete strength requirements.
- C. Testing: If there is evidence that strength of precast concrete members may be deficient or may not comply with ACI 318 requirements, fabricator shall employ an independent testing agency to obtain, prepare, and test cores drilled from hardened concrete to determine compressive strength according to ASTM C 42 and ACI 318.
 - 1. Test results shall be reported in writing on the same day that tests are performed, with copies to Engineer, Contractor, and precast concrete fabricator. Test reports shall include the following:
 - a. Project identification name and number.
 - b. Date when tests were performed.
 - c. Name of precast concrete fabricator.
 - d. Name of concrete testing agency.

- e. Identification letter, name, and type of precast concrete member(s) represented by core tests; design compressive strength; type of failure; actual compressive strength at breaks, corrected for length-diameter ratio; and direction of applied load to core in relation to horizontal plane of concrete as placed.
- D. Patching: If core test results are satisfactory and precast concrete members comply with requirements, clean and dampen core holes and solidly fill with precast concrete mixture that has no coarse aggregate, and finish to match adjacent precast concrete surfaces.
- E. Acceptability. Structural precast concrete members that do not comply with acceptability requirements in PCI MNL 116, including concrete strength, and manufacturing tolerances, are unacceptable. Chipped, spalled or cracked members may be repaired. Replace unacceptable units with precast concrete members that comply with requirements.

PART 3 -- EXECUTION

3.01 PREPARATION

- A. Furnish loose connection hardware and anchorage devices for precast concrete members to be embedded in or attached to the building structural frame or foundation before starting that Work. Provide locations, setting diagrams, templates and instructions for the proper installation of each anchorage device.

3.02 EXAMINATION

- A. Examine supporting structural frame or foundation and conditions for compliance with requirements for installation tolerances, bearing surface tolerances, and other conditions affecting precast concrete performance.
- B. Proceed with precast concrete installation only after unsatisfactory conditions have been corrected.
- C. Contractor shall notify precast concrete erector that supporting cast-in-place concrete foundation and building structural framing has attained minimum allowable design compressive strength or supporting steel or other structure is structurally ready to receive loads from precast concrete members prior to proceeding with installation.

3.03 ERECTION

- A. Install loose clips, hangers, bearing pads, and other accessories required for connecting structural precast concrete members to supporting members and backup materials.
- B. Erect structural precast concrete level, plumb and square within the specified allowable erection tolerances. Provide temporary structural framing, shoring and bracing as required to maintain position, stability, and alignment of members until permanent connections are completed.
 - 1. Install temporary steel or plastic spacing shims or bearing pads as precast concrete members are being erected. Surface weld steel shims to each other to prevent shims from separating.
 - 2. Maintain horizontal and vertical joint alignment and uniform joint width as erection progresses.

3. Remove projecting lifting devices and use plastic patchcaps or sand-cement grout to fill voids within recessed lifting devices flush with surface of adjacent precast concrete surfaces when recess is exposed.
 4. Unless otherwise indicated provide uniform joint widths of $\frac{3}{4}$ in.
 5. Provide and install headers of structural-steel shapes for openings larger than one slab width according to hollow-core slab fabricator's written recommendations.
- C. Connect structural precast concrete members in position by bolting, welding, grouting, or as otherwise indicated on approved Shop (Erection) Drawings. Remove temporary shims, wedges, and spacers as soon as practical after connecting and/or grouting are completed.
1. Disruption of roof flashing continuity by connections is not permitted; concealment within roof insulation is acceptable.
- D. Welding: Comply with applicable AWS D1.1, AWS D1.4 and AWS D1.6 requirements for welding, welding electrodes, appearance of welds, quality of welds, and methods used in correcting welding work.
1. Protect structural precast concrete members and bearing pads from damage during field welding or cutting operations and provide noncombustible shields as required.
 2. Welds not specified shall be continuous fillet welds, using not less than the minimum fillet as specified by AWS D1.1, D1.4 or D1.6.
 3. Clean-weld-affected metal surfaces with chipping hammer followed by brushing or power tool cleaning and then reprime damaged painted surfaces in accordance with manufacturer's recommendations.
 4. Visually inspect all welds critical to precast concrete connections. Visually check all welds for completion and remove, reweld or repair all defective welds, if services of AWS-certified welding inspector are not furnished by Owner.
- E. At bolted connections, use upset threads, thread locking compound or other approved means to prevent loosening of nuts after final adjustment.
1. Where slotted connections are used, verify bolt position and tightness at installation. For sliding connections, properly secure bolt but allow bolt to move within connection slot.
 2. For slip critical connections, one of the following methods shall be used to assure proper bolt pretension:
 - a. Turn-of-Nut – in accordance with AISC.
 - b. Calibrated Wrench – in accordance with AISC.
 - c. Twist-off Tension Control Bolt – meeting ASTM F3125.
 - d. Direct-Tension Control Bolt – meeting ASTM F3125.

3. For slip critical connections, the method to be used and the inspection procedure to be used shall be approved by the Engineer and coordinated with the inspection agency.
- F. Grouting or Dry-Packing Connections and Joints: Indicate joints to be grouted and any critical grouting sequences on Shop (Erection) Drawings. Grout open spaces at keyways, connections and joints where required or indicated. Provide reinforcing steel where indicated. Retain flowable grout in place until it gains sufficient strength to support itself. Fill joints completely without seepage to other surfaces. Alternatively, pack spaces with stiff dry pack grout material, tamping until voids are completely filled. Place grout and finish smooth, level, and plumb with adjacent concrete surfaces. Promptly remove grout material from exposed surfaces before it affects finishes or hardens. Keep grouted joints damp for at least 24 hours after initial set.
1. Trowel top of grout joints on roofs smooth to prevent any unevenness that might interfere with placing of, or cause damage, to insulation and roofing. Finish transitions due to different surface levels not steeper than 1 to 12.
 2. At Hollow-Core Slab Ends (where shown on Drawings): Provide suitable end cap or dam in voids as required.
- G. Field cutting of precast, prestressed concrete members is not permitted without approval of the Engineer.
- H. Fasteners: Do not use drilled or power-actuated fasteners for attaching accessory items to precast, prestressed concrete members unless approved by Precast Engineer and Engineer of Record.

3.04 ERECTION TOLERANCES

- A. Erect structural precast concrete members level, plumb, square, and in alignment without exceeding the noncumulative erection tolerances of PCI MNL 135. Level out variations between adjacent members by jacking, loading, or any other feasible method as recommended by the fabricator and acceptable to the Engineer.

3.05 FIELD QUALITY CONTROL

- A. Special Inspections: Owner will engage a qualified special inspector to perform the following special inspections and prepare reports:
1. Erection of loadbearing precast concrete members.
- B. Testing: Owner will engage accredited independent testing and inspecting agency to perform field tests and inspections and prepare reports.
1. Field welds will be subject to visual inspections and dye penetrant or magnetic particle testing in accordance with ASTM E 165 or ASTM E 1444. Testing agency shall be qualified in accordance with ASTM E543.
 2. Testing agency will report test results promptly and in writing to Contractor and Engineer.
- C. Repair or remove and replace work where tests and inspections indicate that it does not comply with specified requirements.

- D. Additional testing and inspecting, at Erector's expense, will be performed to determine compliance of corrected work with specified requirements.

3.06 REPAIRS

- A. Repairs will be permitted provided structural adequacy, serviceability and durability of members and appearance are not impaired.
- B. Wire brush, clean, and paint damaged prime-painted components with same type of shop primer.
- C. Remove and replace damaged structural precast concrete members when repairs do not comply with specified requirements.

3.07 CLEANING

- A. Erector shall clean mortar, plaster, fireproofing, weld slag, and any other deleterious material from concrete surfaces and adjacent materials immediately.
- B. Erector shall clean exposed surfaces of precast concrete members after erection and completion of joint treatment to remove weld marks, other markings, dirt, and stains.
 - 1. Perform cleaning procedures, if necessary, according to precast concrete fabricator's recommendations. Protect adjacent work from staining or damage due to cleaning operations.
 - 2. Do not use cleaning materials or processes that could change the appearance of exposed concrete finishes or damage adjacent materials.

END OF SECTION

SECTION 03 60 00 – grouting

PART 1 -- GENERAL

1.01 SUMMARY

- A. The Contractor shall provide grout, complete and in place, in accordance with the Contract Documents. For concrete repair material and procedures, reference Section 03 01 00 – Maintenance of Concrete.
- B. Grout provided as a base support for mechanical and electrical equipment shall conform to manufacturer's requirements and the requirements of this section.
- C. The following types of grout are covered in this Section:
 - 1. Neat Cement Grout
 - 2. Non-Shrink Grout
 - 3. High Strength Non-Shrink Grout
 - 4. Non-Shrink Epoxy Grout
 - 5. Topping Grout and Grout Fill

1.02 REFERENCE SPECIFICATIONS, CODES AND STANDARDS

- A. The edition of the standards applicable to the Work shall be those editions referenced by the 2024 Ohio Building Code (OBC). If the standard is not referenced by the OBC, nor an OBC-referenced standard listed below, the edition of the standard applicable to the Work shall be the edition in effect on the date of signing and sealing of the contract specifications.
- B. Reference Specifications

01 33 00	Submittal Procedures
03 01 00	Maintenance of Concrete
03 30 00	Cast-in-Place Concrete
05 05 19	Post-Installed Concrete Anchors

- C. Reference Standards

ASTM International (ASTM)	
ASTM C109	Standard Test Method for Compressive Strength of Hydraulic Cement Mortars (Using 2-in. or [50-mm] Cube Specimens)
ASTM C307	Standard Test Method for Tensile Strength of Chemical-Resistant Mortar, Grouts, and Monolithic Surfacing
ASTM C531	Standard Test Method for Linear Shrinkage and Coefficient of Thermal Expansion of Chemical-Resistant Mortars, Grouts, Monolithic Surfacing, and Polymer Concretes
ASTM C579	Standard Test Methods for Compressive Strength of Chemical-Resistant Mortars, Grouts, Monolithic Surfacing, and Polymer Concretes

ASTM C580	Standard Test Method for Flexural Strength and Modulus of Elasticity of Chemical-Resistant Mortars, Grouts, Monolithic Surfacing, and Polymer Concretes
ASTM C827	Standard Test Method for Change in Height at Early Ages of Cylindrical Specimens of Cementitious Mixtures
ASTM C882	Standard Test Method for Bond Strength of Epoxy-Resin Systems Used with Concrete by Slant Shear
ASTM C1090	Standard Test Method for Measuring Changes in Height of Cylindrical Specimens from Hydraulic-Cement Grout
ASTM C1107	Standard Specification for Packaged Dry, Hydraulic-Cement Grout (Nonshrink)
ASTM C1116	Standard Specification for Fiber-Reinforced Concrete
ASTM C1339	Standard Test Method for Flowability and Bearing Area of Chemical-Resistant Polymer Machinery Grouts
International Concrete Repair Institute (ICRI)	
ICRI 310.2R-2013	Selecting and Specifying Concrete Surface Preparation for Sealers, Coatings, Polymer Overlays, and Concrete Repair

1.03 CONTRACTOR SUBMITTALS

A. Furnish submittals in accordance with Section 01 33 00 – Submittal Procedures.

1. Certified testing lab reports for tests indicated herein.
2. Test results and service report from the field tests and the demonstration and training session verifying the requirements indicated herein.
3. Manufacturer's literature containing instructions and recommendations on the mixing, handling, placement, curing, and appropriate uses for each type of grout used in the Work, and location of use.
4. Documentation indicating that the grouts contain no chlorides or other chemicals that cause corrosion.
5. Manufacturer's Safety Data Sheet documenting composition of grouts.
6. Submit manufacturer's written warranty as indicated herein.

1.04 QUALITY ASSURANCE

A. Field Tests

1. Compression test specimens will be taken from the first placement of each type of grout, and at intervals thereafter selected by the Engineer. The specimens will be made by the Engineer or its representative.
2. Compression tests and fabrication of specimens for cement based non-shrink grout will be performed in accordance with ASTM C1107 at intervals during construction selected by the Engineer.

3. Compression tests and fabrication of specimens for topping grout and grout fill will be performed in accordance with Section 03 30 00 - Cast-in-Place Concrete at intervals during construction selected by the Engineer.
 4. Compression tests and fabrication of specimens for epoxy grouts will be performed in accordance with ASTM C579, Method B, at intervals during construction selected by the Engineer. A set of 3 specimens will be made for testing at 7 Days and each earlier time period as appropriate.
 5. The cost of laboratory tests on grout will be paid by the OWNER except where test results show the grout to be defective. In such case, the Contractor shall pay for the tests, removal and replacement of Defective Work, and re-testing, all as part of the Work.
 6. The Contractor shall assist the Engineer in obtaining specimens for testing and shall furnish materials necessary for fabricating the test specimens.
- B. Construction Tolerances: Construction tolerances shall be as indicated in Section 03 30 00 - Cast-in-Place Concrete unless indicated otherwise.
- C. Pre-Installation Demonstration and Training
1. Non-Shrink Grouts
 - a. The grout manufacturer shall give a demonstration and training session for the cement based and epoxy non-shrink grouts to be used on the project before any installation of grout is allowed.
 - b. The Contractor shall transport the test cubes to an independent test laboratory, obtain the test reports, and report these demonstration and training test cube strengths to the Engineer.

1.05 SPECIAL CORRECTION OF DEFECTS PROVISIONS

A. Manufacturer's Warranty

1. Furnish one year warranty for Work provided under this section.
2. Manufacturer's warranty shall not contain a disclaimer limiting responsibility to the purchase price of products or materials.

PART 2 -- PRODUCTS

2.01 APPLICATION

- A. Unless indicated otherwise, grouts shall be provided as listed below whether indicated on the Drawings or not.

Application	Type of Grout
Beam and column (1 or 2 story) base plates less than 16-inches in the least dimension.	Non-Shrink
Column base plates (greater than 2 story or larger than 16-inches in the least dimension)	High Strength Non-Shrink

Storage tanks and other non-motorized equipment or machinery under 30 horsepower	Non-Shrink
Motorized equipment over 30 horsepower and equipment under 30 horsepower but subject to severe shock loads and high vibrations	Non-Shrink Epoxy
Filling blockout spaces for embedded items such as railing posts, gate guide frames, etc.	Non-Shrink
Toppings and grout fill less than 3-inches thick	Topping Grout
Toppings and grout fill greater than 3-inches thick	Section 2.4 and Structural Concrete per 03 30 00 - Cast-in-Place Concrete
Anchor bolts, anchor rods and reinforcing steel required to be set in epoxy or adhesive.	Post Installed Anchors in Concrete per Section 05 05 19 - Post-Installed Concrete Anchors
Repair of holes and defects in concrete members.	Concrete Repair and Rehabilitation per Section 03 01 00 - Maintenance of Concrete

2.02 NEAT CEMENT GROUT

- A. Neat cement grout shall be composed of one 94 pound bag of cement and 5 gallons minimum to 6 gallons maximum of clean water to obtain the desired consistency.
- B. Cement material and water shall be as indicated in 03 30 00 - Cast-in-Place Concrete.

2.03 NON-SHRINK GROUTS

A. General

1. All non-shrink grout shall be cement based unless otherwise noted.
2. Cement-based non-shrink grout shall be a prepackaged, inorganic, fluid, non-gas liberating, non-metallic, cement type grout requiring only the addition of water. Cement from kilns burning metal-rich hazardous waste fuel shall not be used.
3. Manufacturer's instructions shall be printed on each bag or other container in which the materials are packaged. The specific formulation for each non-shrink grout shall be as recommended by the manufacturer for the particular application.
4. The manufacturer's product information shall state the acceptability of the non-shrink grout for the intended purpose and location.
5. Grout shall not contain chlorides or additives that may contribute to corrosion.
6. Grout placed in continuously wet environments or in exterior conditions shall not contain gypsum or calcium salt.
7. All cement-based non-shrink grout shall have the following general properties:
 - a. Meet the requirements of ASTM C1107.

- b. Have a maximum early age height change of 4.0 percent expansion, and shall have no shrinkage (0.0 percent) in accordance with ASTM C827. The grout when tested shall not bleed or segregate at maximum allowed water.
 - c. No shrinkage (0.0 percent) and a maximum of 0.3 percent expansion in the hardened state when tested in accordance with ASTM C1090.
 - d. A minimum bond strength (concrete to grout) of 1900 psi per modified ASTM C882.
- 8. Environmental and ambient conditions shall be a factor in the selection of non-shrink grout. If a non-shrink grout is to be used in a high temperature environment or freeze/thaw environment, the manufacturer's product information shall state the acceptability for each environmental condition.
- 9. Grout shall be suitable for use in freeze/thaw environments.
- B. Non-Shrink Grout
 - 1. Non-Shrink Grout shall have a minimum 28 Day compressive strength of 5000 psi when mixed at a fluid consistency and tested per ASTM C109.
 - 2. Non-Shrink Grout shall be Five Star Grout by Five Star Products, Inc., Fluid Grout 100 by Five Star Products, Inc., SikagROUT 212 by Sika Corporation, or approved equal.
- C. High Strength Non-Shrink Grout
 - 1. High Strength Non-Shrink Grout shall have a minimum 28-Day compressive strength of 10,000 psi when mixed at a fluid consistency and tested per ASTM C109.
 - 2. High Strength Non-Shrink Grout shall be High Strength Grout by Five Star Products, Inc., SikagROUT 428 FS by Sika Corporation, or approved equal.

2.04 NON-SHRINK EPOXY GROUT

- A. Non-shrink epoxy grout shall develop a minimum compressive strength of 9000 psi in 24 hours and 13,000 psi in seven days when tested in accordance with ASTM C579, method B.
- B. Non-shrink epoxy grout shall be a flowable, non-shrink, 100 percent solids system. The epoxy grout system shall have 3 components: resin, hardener, and specially blended aggregate, each premeasured and prepackaged. The resin component shall not contain any non-reactive diluents.
- C. The manufacturer's product information shall state the acceptability of the epoxy grout for the intended purpose and location.
- D. Variation of component ratios is not permitted unless specifically recommended by the manufacturer. Manufacturer's instructions shall be printed on each container in which the materials are packaged.
- E. Resins containing butyl glycidyl ether (BGE) or other highly volatile and hazardous reactive diluents are not acceptable.

- F. Non-shrink epoxy grout shall have a negligible (less than 0.0006 in/in) length change after hardening, and a coefficient of thermal expansion less than 0.00003 in/in F when tested in accordance with ASTM C531.
- G. The effective bearing area shall be a minimum of 85 percent effective bearing area (EBA) in accordance with ASTM C1339, for bearing area and flow.
- H. The chemical formulation of the non-shrink epoxy grout shall be that recommended by the manufacturer for the particular application. Do not reduce aggregate loading or add solvents to increase flowability.
- I. Non-shrink epoxy grout shall have the following minimum properties when tested at 7 Days:
 - 1. Minimum bond strength to concrete of 3000 psi per ASTM C882 modified.
 - 2. Minimum bond strength to steel of 1700 psi per ASTM C882 modified.
 - 3. Minimum flexural strength of 2500 psi per ASTM C580.
 - 4. Minimum tensile strength of 2000 psi per ASTM C307.
- J. Non-shrink epoxy grout shall be DP Epoxy Grout by Five Star Products, Inc., MasterFlow 648 by BASF/Master Builders, Sikadur 42 Grout-Pak by Sika Corporation, or approved equal.

2.05 TOPPING GROUT AND GROUT FILL

- A. Topping grout and grout fill for built-up surfaces of tanks, channels, and basin bottoms shall be composed of cement, fine aggregate, coarse aggregate, water, and admixtures proportioned and mixed as indicated. Materials and procedures indicated for structural concrete in Section 03 30 00 - Cast-in-Place Concrete, shall apply unless indicated otherwise.
- B. Topping grout used in clarifiers, or where the fill thickness is 3 inches or greater shall contain fiber reinforcing, unless otherwise shown on the Contract Documents. Fiber reinforcing shall be 100 percent virgin polypropylene fibrillated fibers specifically manufactured in a blended gradation for use as concrete secondary reinforcement. Fibers shall be added at a rate of 1.5 pounds per cubic yard of concrete. Fibers shall conform to ASTM C1116.
- C. For topping grout and grout fill thickness greater than 3-inches, ready-mix concrete may be used with the following requirements:
 - 1. Strength: Minimum compressive strength of topping grout and grout fill at 28 days shall be 4500 psi.
 - 2. Minimum of 564 pounds of cement per cubic yard with a maximum water/cement ratio of 0.45.
 - 3. Coarse aggregate shall be as follows:

U.S. Standard Sieve Size	Percent By Weight Passing
1/2 in	100
3/8 in	90-100
No. 4	20-55
No. 8	5-30
No. 16	0-10
No. 30	0

- D. Final mix design shall be as determined by trial mix design as indicated in Section 03 30 00 - Cast-in-Place Concrete, except that drying shrinkage tests are not required.
- E. Topping grout and grout fill shall contain air-entraining agent per Section 03 30 00 - Cast-in-Place Concrete.

2.06 CURING MATERIALS

- A. Curing materials shall be in accordance with Section 03 30 00 - Cast-in-Place Concrete and as recommended by the manufacturer of prepackaged grouts.

2.07 CONSISTENCY

- A. The consistency of grout shall be as necessary to completely fill the space to be grouted for the particular application. Dry pack consistency is defined such that the grout is plastic and moldable but will not flow. Where "dry pack" is called for in the Contract Documents, it shall mean a grout of that consistency; the type of grout to be used shall be as indicated herein for the particular application.
- B. The slump for topping grout and grout fill shall be adjusted to match placement and finishing conditions but shall not exceed 4-inches.

2.08 MEASUREMENT OF INGREDIENTS

- A. Measurements shall be made accurately by volume using containers. Shovel measurements are not allowed.
- B. Prepackaged grouts shall have ingredients measured by means recommended by the manufacturer.

PART 3 -- EXECUTION

3.01 PRODUCT DELIVERY, STORAGE AND HANDLING

- A. Grout shall be stored in accordance with manufacturer's recommendations.

3.02 GENERAL

- A. Contractor shall arrange for the manufacturer of prepackaged grouts to provide on-site technical assistance within 72 hours of request, as part of the Work.
- B. Grout shall not be placed until base concrete or masonry has attained its design strength, unless authorized otherwise by the Engineer.

- C. When cementitious grouts are used on concrete surfaces, the concrete surface shall be saturated with water for 24 hours prior to placement. Upon completion of the saturation period, excess water shall be removed with clean, oil free compressed air prior to grouting. Concrete substrate shall not be wet prior to placement of epoxy grouts.
- D. Surface preparation, curing, and protection of cement based grout shall be in accordance with Section 03 30 00 - Cast-in-Place Concrete. The finish of the grout surface shall match that of the adjacent concrete unless otherwise indicated.
- E. Surfaces that will be in contact with grout shall be free of dirt, loose rust, oil, wax, grease, curing compounds, laitance, loose concrete, and other deleterious materials.
- F. Shade the Work from sunlight for at least 24 hours before and 48 hours after grouting.
- G. Contact the grout manufacturer's representative for assistance on hot and cold weather grouting techniques and precautions if applicable.

3.03 GROUTING PROCEDURES

- A. General: Mixing, surface preparation, handling, placing, consolidation, curing, and other means of execution for prepackaged grouts shall be done according to the instructions and recommendations of the manufacturer.
- B. Structural, equipment, tank, and piping support bases shall be grouted, unless indicated otherwise.
 - 1. The original concrete shall be blocked out or finished off a sufficient distance below the plate to provide for a minimum one-inch thickness of grout or other thickness if indicated.
 - 2. After the base plate has been set in position at the proper elevation by steel wedges or double nuts on the anchor bolts, the space between the bottom of the plate and the original pour of concrete shall be filled with non-shrink-type grout through a headbox of appropriate size. The mixture shall be of a fluid consistency and poured continuously into the space between the plate and the base concrete. Forms for grout shall be tight against retaining surfaces, and joints shall be sealed as recommended by the grout manufacturer to be liquid-tight. Forms shall be coated as recommended by the grout manufacturer for easy form release. Where this method of placement is not practical or where required by the Engineer, alternate grouting methods shall be submitted by the Contractor for acceptance by the Engineer.
 - 3. Concrete equipment pads for equipment bases that will be epoxy-grouted shall be sized so that, when the equipment base is fully grouted, the epoxy grout is stopped not less than 4-inches from the edge of the pad.
- C. Topping Grout and Grout Fill
 - 1. Mechanical, electrical, and finish Work shall be completed prior to placement of topping grout or grout fill.

2. To ensure bonding to the base slab, the base slab shall have a roughened surface to a ¼-inch amplitude. The base slab shall be thoroughly cleaned and wetted to saturated surface dry (SSD) condition per ICRI 310.2R-2013 prior to placing topping grout and grout fill. No topping grout shall be placed until the slab is completely free from standing pools or ponds of water. A thin coat of neat cement grout shall be broomed into the surface of the slab just before topping or fill placement. The neat cement grout shall not be allowed to dry before topping placement. If it does dry, it must be immediately removed using wet stiff brooms and reapplied.
3. The topping and fill shall be compacted by rolling or thorough tamping, brought to established grade, and floated. Grouted fill for tank and basin bottoms where scraping mechanisms are to be installed shall be screeded by blades attached to the revolving mechanism of the equipment in accordance with the procedures outlined by the equipment manufacturer after the grout is brought to the established grade. Coat surface with evaporation retardant as needed to prevent plastic shrinkage cracks.
4. The minimum thickness of grout topping and grout fill shall be one-inch. Where the finished surface of grout fill is to form an intersecting angle of less than 45 degrees with the concrete surface it is to be placed against, a key shall be formed in the concrete surface at the intersection point. The key shall be a minimum of 3-1/2 inches wide by 1-1/2 inches deep.
5. Topping grout placed on sloping slabs shall proceed uniformly from the bottom of the slab to the top, for the full width of the placement.
6. The surface shall be tested with a straight edge to detect high and low spots which shall be immediately eliminated. When the topping or fill has hardened sufficiently, it shall be steel troweled to a smooth surface free from pinholes and other imperfections. An approved type of mechanical trowel may be used as an assist in this operation, but the last pass over the surface shall be by hand-troweling. During finishing, no water, dry cement, or mixture of dry cement and sand shall be applied to the surface.
7. As soon as topping or fill finishing is completed, coat surface with curing compound. After the topping is set and sufficiently hard in clarifiers and where required by the Engineer, the tank shall be filled with sufficient water to cover the entire floor for 14 days.

3.04 CONSOLIDATION

- A. Grout shall be placed in such a manner, for the consistency necessary for each application, to assure that the space to be grouted is completely filled.

END OF SECTION

SECTION 04 05 19.16 – MASONRY ANCHORS

PART 1 -- GENERAL

1.01 SUMMARY

- A. Provide post-installed anchors and appurtenances, complete and in place, as indicated in accordance with the Contract documents.
- B. Unless otherwise indicated, drilled masonry anchors shall be adhesive anchors.
- C. Section Includes:
 - 1. Adhesive anchors
 - 2. Expansion anchors
 - 3. Screw anchors

1.02 REFERENCE SPECIFICATIONS, CODES AND STANDARDS

A. Definitions

- 1. Epoxy anchors are considered adhesive anchors.
- 2. Expansion anchors, screw anchors, and undercut anchors are considered mechanical anchors.

B. Reference Specifications

01 33 00	Submittal Procedures
01 33 17	Structural Design, Support and Anchorage
03 01 00	Maintenance of Concrete
03 21 00	Reinforcement Bars
03 30 00	Cast-in-Place-Concrete
05 50 00	Metal Fabrications

C. Reference Standards

- 1. The edition of the standards applicable to the Work shall be the edition referenced by the 2024 Ohio Building Code (IBC). If the standard is not referenced by the OBC, nor an OBC-referenced standard listed below, the edition of the standard applicable to the Work shall be the edition in effect on the date of signing and sealing of the contract specifications.

Building Code	
OBC	2024 Ohio Building Code
American Concrete Institute (ACI)	
ACI 530	Building Code Requirements for Masonry Structures (TMS 402/ACI 530-ASCE 5)
ACI 530.1	Specification for Masonry Structures (TMS 602/ACI 530.1/ASCE 6)

American Society of Civil Engineers (ASCE)	
ASCE 7-16	ASCE/SEI 7 - Minimum Design Loads for Buildings and Other Structures with Supplement No. 1
ASTM International (ASTM)	
ASTM E 3121	Standard Test Methods for Field Testing of Anchors in Concrete or Masonry
International Code Council (ICC)	
ICC ES AC01	Acceptance Criteria for Expansion Anchors in Masonry Elements
ICC ES AC58	Acceptance Criteria for Adhesive Anchors in Masonry Elements
ICC ES AC106	Acceptance Criteria for Predrilled Fasteners (Screw Anchors) in Masonry Elements

1.03 SUBMITTALS

- A. Furnish submittals in accordance with Section 01 33 00 – Submittal Procedures.
- B. Submit the following:
 1. Product data and technical information
 2. Safety Data Sheets (SDS) for adhesives
 3. Manufacturer's literature containing installation instructions and appropriate uses for each type of post-installed anchor and location of use
 4. Current International Code Council Evaluation Service (ICC-ES) or International Association of Plumbing and Mechanical Officials Uniform Evaluation Service (IAPMO-UES) Evaluation Reports
 5. Certification for each installer demonstrating that they have been qualified in accordance with the Quality Assurance requirements below
- C. No substitution for the indicated anchors will be considered unless accompanied with an ICC-ES or IAPMO-UES report verifying strength and material equivalency.
- D. Complete structural calculations and anchorage details shall be prepared and submitted by the Contractor for all anchors and anchor groups that are shown but not completely detailed (type, size, location, spacing and embedment) on the Contract Documents. Calculations and anchorage details shall be completed and submitted in accordance with Section 01 33 17 – Structural Design, Support and Anchorage.
 1. Where adhesive anchors are used for structural applications and an embedment depth is not shown on the contract documents, the anchor shall be installed in accordance with Method 1 or Method 2 below:
 - a. Method 1: The minimum depth of embedment shall be greater than or equal to the development length (l_d) determined in accordance with ACI 530 for a cast in place reinforcing bar of the same diameter and grade, unless it can be shown by calculation that the anchor spacing and edge distance is sufficient to develop the tensile strength of the anchor in a lesser depth of embedment.

- b. Method 2: Adhesive anchors in masonry that cannot develop the tensile capacity of the steel element may be used to transfer forces, provided that:

- 1) For new structures, the anchor is designed in accordance with ASCE 7-16.

1.04 QUALITY ASSURANCE

- A. Special inspection for all post-installed anchor installations shall be provided:
 - 1. As recommended or required by the ICC-ES or IAPMO-UES report.
 - 2. As required by the enforceable building code.
 - 3. As otherwise indicated in the Contract Documents.
- B. The most stringent of the above requirements shall be used. The cost of Special Inspection of post-installed anchors shall be paid for by the owner.
- C. Before installing adhesive anchors in the work, anchor installers shall be trained and qualified at the Site by the manufacturer's representative. Training and qualification for each installer shall include at least:
 - 1. Hole drilling procedure, hole preparation and cleaning techniques, adhesive injection technique and dispenser training/maintenance, rebar dowel preparation and installation, and proof loading if required.
 - 2. Each installer shall be re-qualified every 6 months for the duration of the project by the same qualifying procedure.
- D. Before installing mechanical anchors in the work, anchor installers shall be trained and qualified at the Site by the manufacturer's representative. Training and qualification for each installer shall include at least:
 - 1. Hole drilling procedure, hole preparation and cleaning techniques, and torqueing.
 - 2. Each installer shall be re-qualified every 6 months for the duration of the project by the same qualifying procedure.
- E. Defective anchors noted by the Special Inspector shall be replaced and re-installed by the contractor without any additional compensation.

1.05 DELIVERY, STORAGE, AND HANDLING

- A. Deliver products to job site in manufacturer's or distributor's packaging undamaged, complete with installation instructions.
- B. Protect and handle materials in accordance with manufacturer's recommendations to prevent damage or deterioration.
- C. Anchoring adhesives shall be stored at temperatures prescribed by the manufacturer and must not be used beyond the expiration date.

1.06 SITE CONDITIONS

- A. Post-installed anchors shall be installed in grout filled, concrete masonry having the minimum age required by the ICC-ES or IAPMO-UES report, or manufacturer's instructions, at the time of anchor installation.
- B. The anchor or fastener coating, plating, or steel type must provide suitable corrosion resistance for the environment in which the anchor or fastener is installed. Anchors, nuts, and washers in the locations listed below shall be fabricated from type 316 or 304 stainless steel:
 - 1. buried locations
 - 2. submerged locations
 - 3. locations subject to seasonal or occasional flooding
 - 4. inside buried vaults, manholes, and structures that do not drain through a gravity sewer or to a sump with a pump
 - 5. chemical handling areas
 - 6. inside trenches, containment walls, and curbed areas
 - 7. locations indicated or designated by the Engineer to be provided with stainless steel anchors.

PART 2 -- PRODUCTS

2.01 ADHESIVE ANCHORS

- A. General
 - 1. The adhesive anchor system shall consist of: 1) adhesive product; and 2) threaded rod or reinforcing bar insert. The complete system shall be compatible as required by the adhesive manufacturer.
 - 2. Adhesives shall be injectable, two-component, cartridge-type systems dispensed and mixed through a static mixing nozzle supplied by the manufacturer.
 - 3. The evaluation report issued by ICC-ES or IAPMO-UES shall state the acceptability of the adhesive anchor for the intended purpose and location.
 - 4. Adhesive anchors shall be permitted when regular ambient temperatures are consistent with manufacturer's recommendation for long and short term temperatures.
 - 5. Adhesive anchors shall not be used where anchors are subject to vibration or fire.
 - 6. Adhesive anchors shall not be used in overhead applications.
 - 7. Adhesive shall be capable of being used in submerged applications once cured.
- B. Adhesive Anchors in Grout Filled Concrete Masonry Units

1. Threaded rod inserts shall meet the requirements of Section 05 50 00 – Metal Fabrications.
2. Reinforcing dowel inserts shall meet the material requirements of Section 03 21 00 – Reinforcement Bars and 03 30 00 – Cast-in-Place Concrete.
3. Adhesive anchors shall have an evaluation report issued by ICC-ES or IAPMO-UES and shall have been tested and qualified for performance in grout-filled and hollow (ungrouted) concrete masonry units in accordance with ICC-ES AC58.
4. Adhesive anchors for masonry shall be AC100+ Gold by DeWalt/Powers Fasteners, HIT-HY 270 by Hilti, SET-XP by Simpson Strong-Tie, or equal.

2.02 EXPANSION ANCHORS

A. General

1. Expansion anchors are post-installed torque-controlled mechanical expansion anchors used to resist structural loads.
2. Expansion anchors shall be an imperial sized, threaded stud with an integral cone expander, expansion clip, nut and washer.
3. Lead caulking anchors will not be permitted.
4. Non-embedded buried or submerged anchors shall be fabricated from stainless steel.
5. The evaluation report issued by ICC-ES or IAPMO-UES shall state the acceptability of the expansion anchor for the intended purpose and location.
6. Anchors subjected to dynamic or vibratory loading shall be suitable for the intended loading and location as indicated in the manufacturer's technical product data.

B. Expansion Anchors for Grout Filled Concrete Masonry Units

1. Anchors shall have an evaluation report issued by ICC-ES or IAPMO-UES and have been tested and qualified for performance in grout filled, uncracked concrete masonry units in accordance with ICC-ES AC01.
2. Expansion anchors for grout filled concrete masonry shall be Strong-Bolt 2 by Simpson Strong-Tie, Kwik-Bolt TZ by Hilti, Power-Stud+ SD1 by DeWalt/Powers Fasteners, or equal.

2.03 SCREW ANCHORS

A. General

1. Screw anchors used in exterior and corrosive environments shall be fabricated from stainless steel.
2. The evaluation report issued by ICC-ES or IAPMO-UES shall state the acceptability of the screw anchor for the intended purpose and location.

3. Anchors subjected to dynamic or vibratory loading shall be suitable for the intended loading and location as indicated in the manufacturer's technical product data.

B. Screw Anchors for Grout Filled Concrete Masonry

1. Anchors shall have an evaluation report issued by ICC-ES or IAPMO-UES and have been tested and qualified for performance in grout filled concrete masonry in accordance with ICC-ES AC106.
2. Screw anchors for grout filled concrete masonry shall be Titen HD by Simpson Strong-Tie, Kwik HUS-EZ (KH-EZ) by Hilti, Screw Bolt + by DeWalt/Powers, or equal.

PART 3 -- EXECUTION

3.01 INSTALLATION REQUIREMENTS

- A. Post-installed anchors shall be installed in strict accordance with the manufacturer's instructions, the ICC-ES or IAPMO-UES report, and project specific design requirements indicated on the Contract Documents or in the design calculations provided by the contractor.
- B. Where holes are drilled in masonry, holes shall be accurately and squarely drilled, and the holes shall be cleaned in accordance with the manufacturer's recommendations.
- C. Acceptable installation and performance temperature ranges shall be verified with manufacturer's literature prior to installation. Minimum substrate temperatures shall be maintained during the full curing period as required by the manufacturer.
- D. Adhesive anchors shall not be loaded until the adhesive has reached its indicated strength in accordance with the manufacturer's instructions.
- E. The contractor shall locate items and identify the position of reinforcing steel and other embedded items prior to drilling holes. Care shall be exercised in drilling to avoid damaging reinforcing or embedded items. The location of drilled holes shall be adjusted to avoid drilling through or cutting any reinforcing bars or embedded items. Notify the Engineer if reinforcing steel or other embedded items are encountered during drilling. Take precautions as necessary to avoid damaging prestressing tendons, electrical and communications conduit, and piping.
- F. Core drilling of holes is not allowed.
- G. Identification of reinforcing steel and/or embedded items, relocation of drilled holes and adjustments or modifications to anchored or fastened items shall be considered part of the Work and shall be provided at no additional cost to the Owner.
- H. All abandoned drilled holes shall be repaired in accordance with Section 03 01 00 - Maintenance of Concrete at no additional cost to the Owner.

END OF SECTION

SECTION 04 21 13 – BRICK MASONRY

PART 1 -- GENERAL

1.01 SUMMARY

- A. The Contractor shall provide brick masonry and appurtenant Work, complete and in place, in accordance with the Contract Documents.

1.02 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

- A. The edition of the standards applicable to the Work shall be those editions referenced by the 2024 Ohio Building Code (IBC). If the standard is not referenced by the IBC, nor an IBC-referenced standard listed below, the edition of the standard applicable to the Work shall be the edition in effect on the date of signing and sealing of the contract specifications.

B. Reference Specifications

01 33 00	Submittal Procedures
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C. Reference Standards

ASTM International (ASTM)	
ASTM A82	Steel Wire, Plain, for Concrete Reinforcement
ASTM A116	Zinc-Coated (Galvanized) Steel Woven Wire Fence Fabric
ASTM A153	Zinc Coating (Hot Dip) on Iron and Steel Hardware
ASTM A615	Deformed and Plain Billet-Steel Bars for Concrete Reinforcement
ASTM C5	Quicklime for Structural Purposes
ASTM C62	Building Brick (Solid Masonry Units Made from Clay or Shale)
ASTM C67	Method of Sampling and Testing Brick and Structural Clay Tile
ASTM C144	Aggregate for Masonry Mortar
ASTM C150	Portland Cement
ASTM C207	Standard Specification for Hydrated Lime for Masonry Purposes
ASTM C404	Standard Specification for Aggregates for Masonry Grout
ASTM C595	Blended Hydraulic Cement
International Code Council (ICC)	
IBC	2021 International Building Code (Basis of Ohio Building Code)

1.03 CONTRACTOR SUBMITTALS

- A. Furnish submittals in accordance with Section 01 33 00 – Submittal Procedures.

1. The Contractor is responsible for all costs associated with material testing for submittals indicated herein.

B. Samples

1. Samples of brick masonry units and mortar for approval and selection of colors and textures. The Engineer may select more than one color and/or texture if desired.
2. A free-standing, minimum 4-ft square 12-inches high sample panel of the masonry work with at least one 90 degree corner, shall be prepared for approval. The sample panel shall remain at the Site and shall be kept in good condition until the completion and final acceptance of the masonry Work.

C. Documentation

1. Reports from testing brick masonry units
2. Reports from testing grout and mortar

1.04 QUALITY ASSURANCE

- A. Applicable Standards: Brick masonry shall conform to the IBC, TMS 402, TMS 602, and other applicable codes and standards of the governing authorities.
- B. Matching Existing Work: Where the brick Work is required to match existing brick and/or brick work, the Contractor shall, prior to Bid submittal, visit the Site or otherwise verify the existing brick and brick work so that the Bid will include the required matching.
- C. Sampling and Testing: In order to assure compliance with governing codes and specifications, material sampling and testing shall be performed by a reputable testing laboratory approved by the Engineer. Costs of sampling, testing, and test reports shall be paid for by the Contractor as part of the Work. The costs of any additional tests and reports requested by the Engineer will be paid by the Owner if said tests and reports verify Contractor compliance with the requirements of the Contract Documents. When tests and reports indicate non-compliance, the costs thereof shall be paid by the Contractor.
- D. Masonry Unit Testing: Brick masonry units shall be sampled and tested in accordance with the requirements of ASTM C67.
- E. Mortar and Grout Testing: Mortar and grout shall be sampled and tested as follows:
 1. At the commencement of the masonry work: At least 2 test samples each of mortar and grout shall be taken on 3 successive Days.
 2. At any change in materials or job conditions: At least 2 samples of each modified material, grout and mortar shall be tested.
 3. Four random tests each of mortar and grout shall be made. The random test samples shall be taken when requested by the Engineer.
 4. Additional samples and tests may be required whenever, in the judgment of the Engineer, additional tests (beyond the random tests) are necessary to determine the quality of the materials.

5. Mortar and grout samples shall be stored in a moist environment until tested, unless directed otherwise by the Engineer or testing laboratory. Tests shall be in accordance with ASTM C144. Prisms shall be made in accordance with ASTM C1314.

1.05 MATERIAL STORAGE

- A. Cement, lime, and other calcareous materials shall be delivered and stored in dry, weather-tight sheds or enclosures, in unbroken bags, barrels, or other approved containers which are plainly marked and labeled with the manufacturers' names and brands. Mortar and grout shall be stored and handled in a manner which will prevent the intrusion of foreign materials and damage by water or dampness. Brick units shall be handled with care to avoid chipping and breakage and shall be stored as directed in the Masonry Design Manual. Materials shall be protected from contact with the earth and exposure to the weather and shall be kept dry and clean until used. Materials stored on newly constructed floors shall be stacked in such a manner that the uniformly-distributed loading does not exceed 30 psf.

PART 2 -- PRODUCTS

2.01 BRICK

- A. Face Brick: Face brick shall conform to ASTM C216 and the following requirements:
 1. Grade: SW.
 2. Type: FBS (Face Brick Standard)
 3. Size: 2 1/4-inch by 3 5/8-inch by 7 5/8-inch.
 4. Color: Brown to red to tan color ranges as selected by the Engineer.
- B. Veneer Brick: Veneer brick shall be face brick as indicated above, unless otherwise indicated.

2.02 REINFORCEMENT STEEL

- A. Wire Devices: Wire devices shall be factory-fabricated from steel wire conforming to the requirements of ASTM A82. Wire devices in walls shall be formed wire that has been zinc coated in accordance with ASTM A116, Class (1).
 1. Centering clips shall be formed from wire not lighter than 9-gauge. Clips shall be of a design that will prevent displacement of the reinforcing bars during construction.
 2. Wire anchors for use with embedded slots or wire inserts shall be formed from looped and closed wire not lighter than 9 gauge.
- B. Veneer Ties: Veneer ties shall be provided as required by local building code and as follows:
 1. Ties for veneer brick connected to concrete or concrete block masonry shall be Dur-O-Wal Rectangular Type, AA Wire Products Company Type AA 301, or equal.

2.03 MORTAR AND GROUT

A. Mortar

1. Mortar for brick masonry shall be Type S with a minimum 28 Day compressive strength of 1800 psi. Proportions shall be one part portland cement; 1/4- to 1/2-part lime paste or hydrated lime; and damp, loose sand in an amount (by volume) not less than 2-1/4 times nor more than 3 times the sum of the cement and lime volumes used. Water shall be carefully proportioned as needed to produce the required workability and strength.
2. Color of mortar shall be selected by the Engineer.

B. Grout: Grout shall have a minimum 28 Day compressive strength of 2000 psi. Proportions shall be one part portland cement, not more than 1/20 part lime paste or hydrated lime; 2-1/4 to 3 parts (by volume) damp loose sand; and not more than 2 parts (by volume) pea gravel. Water shall be proportioned to produce a consistency that will allow pouring without segregation of components. Where the grout space is less than 4-inches, the pea gravel shall be omitted. Grout shall have a slump of 9-inches plus or minus one-inch and shall be cohesive and homogeneous.

C. Transit-Mixed Grout: Transit-mixed grout shall be continually rotated at idle speed from the time the water is added until the grout is discharged.

2.04 MISCELLANEOUS MATERIALS

A. Portland Cement: Portland Cement shall be Type I or II, low alkali, Portland Cement conforming to ASTM C150. Masonry cements or plastic cements will not be permitted. White cement, where called for, shall be White Portland Cement meeting the same requirements.

1. Where Portland Cement meeting the criteria listed above is not readily available, direct substitution for a Blended Hydraulic Cement Type IL, conforming to ASTM C595 shall be allowed with notification to the Engineer within the transmittal of the material product data submittals required herein.

B. Quick Lime: Quick lime shall conform to ANSI/ASTM C5.

C. Hydrated Lime: Hydrated lime shall be Type B conforming to ASTM C207.

D. Aggregates: Sand shall conform to ASTM C144. Coarse aggregate shall conform to ASTM C404.

E. Water: Water for mixing into mortar or grout shall be clear, potable water.

F. Admixtures: Admixtures for use in mortar and grout shall conform to the following requirements:

1. Mortar: Master Builders PS-235 or Rheomix-235, Sika Company Sika-Red Label, or equal.
2. Grout: Sika Company Sika Grout Aid, Type II, Master Builders Pozzoloth normal; or equal.

3. Coloring Admixture for Mortar: Pure, non-fading oxide pigments provided in sealed packages providing accurate measured amounts for uniform mix proportioning and color.

PART 3 -- EXECUTION

3.01 MISCELLANEOUS REQUIREMENTS

- A. Weather Conditions: Work shall be performed only under weather conditions meeting the requirements of the Building Code and referenced standards and be subject to the approval of the Engineer.
- B. Embedded Items: The Contractor shall set or embed required anchors, bolts, reglets, sleeves, conduits, and other items in the Work.
- C. Brick Cutting: Brick cutting shall be by machine.
- D. Brick Protection: Units shall be supported off the ground and shall be covered to protect them from rain. Only clean, dry, uncracked units shall be incorporated in the Work.
- E. Foundation Preparation
 1. Immediately before starting Work, the concrete upon which the masonry will be laid shall be cleaned with water under pressure.
 2. The foundation for the wall shall be clean, rough, and level. Sand-blasting or other means shall be utilized as necessary to remove laitance or other foreign material or to render the foundation sufficiently rough.
 3. The foundation shall be sufficiently level such that the bed joint thickness is between 1/4-inch and 3/4-inch. The foundation face shall be sufficiently true so that the masonry face projects nowhere more than 1/4-inch.
- F. Admixtures: Admixtures for mortar and grout, when allowed, shall be used in accordance with the manufacturer's printed recommendation.
 1. Mortar admixtures may be used only when approved by the Engineer and local Building Department.
 2. Grout admixtures may be used only when approved by the Engineer where the brick has high absorption or the wall is being grouted by the high lift method. In these cases, an admixture shall be used to reduce grout shrinkage.
- G. Reinforcement
 1. Horizontal joint reinforcement shall be as required by the Building Code or as indicated.
 2. Reinforcement bars, including projecting reinforcement dowels, shall be free of loose rust and scale and oil, paint, laitance, dirt, concrete, or other material that will inhibit bond. Dowels shall be in proper location prior to start of masonry Work.

- H. Mortar and Grout Proportioning: Mortar and grout proportioning shall be uniformly and accurately made. Shovel measurements shall not be used. Proportions shall be accurately controlled and maintained.

3.02 BRICK LAYING

- A. Brick Surface Conditions: Surface conditions of the brick shall be maintained or prepared so as to promote the quality of the finished construction and shall conform to the following requirements:
1. Freedom from foreign or loose material: Brick shall be clean and free of dust, dirt, or other foreign materials before laying.
 2. Surface moisture of bricks: When being laid, the brick shall have suction sufficient to hold the mortar and to absorb water from the mortar and grout, but shall be sufficiently damp so that the mortar will remain plastic enough to permit the brick to be leveled and plumbed without destroying bond immediately after being laid.
- B. Alignment: Brick Work shall be plumb, level, and true to line, and corners and angles shall be square unless otherwise indicated.
1. Line blocks shall be used whenever possible. When it is absolutely necessary to use a line pin, the hole in the joint shall be filled with mortar immediately after the pin is withdrawn.
 2. Both outer wythes of a brick wall shall be laid to a line.
- C. Patterns and Details: Pattern work, bonds, or special details indicated on the Drawings shall be accurately executed. Bonding headers shall not be used in grouted masonry.
- D. Joints and Mortaring: Mortaring and joint development shall be as follows:
1. Mortar for bed joints shall be beveled. Beveled bed joints shall be sloped toward the center of the wall in such a manner that the bed joints will be filled when the brick is finally brought to line. Furrowing of bed joints will not be permitted. The protrusion of fins of bed joint mortar into the grout space shall be avoided. If they occur, they shall be left in place if not projecting more than the bed joint thickness. In no case shall they be cut off and dropped onto the grout below.
 2. Head joints, regardless of thickness, shall be completely filled with mortar or grout.
 3. Brick in stretcher (flat-wise) courses shall be shoved into place.
 4. Bricks that are moved or shifted shall be relaid in fresh mortar.
- E. Adjoining Work Protection: Adjoining Work, including door jams and corners, shall be protected from damage or disturbance during the masonry Work. Sills, ledges, offsets, etc., shall be protected from droppings of mortar.

3.03 GROUTING - GENERAL

- A. Grout Consistency: The consistency of grout shall be adjusted so that it will flow into place without segregation of ingredients. Water may be added to compensate for loss, but grout that has begun final set and becomes hard shall not be used.

- B. Grouting Courses: Grout shall be stopped approximately 1-inch below the top of the last brick course except at the finishing course. At the finished course the last grout pour shall be brought flush with the top of the brick.
- C. Protection of Masonry Surfaces: Whenever possible, grouting shall be done from the inside face of the masonry. Extreme care shall be used to prevent any grout or mortar from staining the face of masonry to be left exposed or unpainted. If any grout or mortar does contact the face of such masonry, it shall be removed immediately with fresh water and a stiff vegetable fiber brush. Sills, ledges, offsets, etc., shall be protected from droppings of grout.

3.04 JOINERY

- A. At the time of laying, masonry shall have the mortar joints finished as indicated. Defective joints shall be cut out and repointed. Joints having holes such as made by line pins shall be pointed and tooled properly. Regardless of other jointing indicated, jointing in masonry surfaces that are exposed to the weather shall be tooled, making solid, smooth, watertight, compact joints. Tooled joints shall be made by striking them with a metal jointing tool to produce "Concave" finished joints.
 - 1. Vertical and horizontal joints shall be 3/8-inch wide unless otherwise indicated.
 - 2. Flush joints, which shall be made by cutting off the mortar flush with the face of the work with a trowel, may be used in non-exposed masonry and masonry that will subsequently be plastered.

3.05 POINTING AND CLEANING

- A. At the completion of the work holes or defective mortar joints in exposed masonry shall be pointed. Defective joints shall be cut out and repointed.
- B. Exposed masonry shall be protected against staining from wall grouting or other sources and excess mortar shall be cleaned off the surfaces as the Work progresses.
- C. At the completion of the Work, exposed masonry shall be cleaned using a dilute acid solution. In the event that ordinary acid wash cleaning is not adequate, special methods such as sandblasting or chipping shall be used to facilitate cleaning.
- D. Waste and surplus masonry materials shall be removed from the Site, and stains or dirt from this operation affecting adjacent surfaces shall be removed by an approved cleaning method.
- E. If the sample panel is not part of the wall system, it shall be removed from the Site after completion and acceptance of the masonry Work.

3.06 SITE QUALITY CONTROL

- A. Inspection and Testing: Whenever required under the provisions of the Building Code or these contract documents, Work hereunder will be subject to inspection by the Special Inspector. Special inspection will be performed as required by the Drawings, TMS 402/602, Level 2 Quality Assurance and the enforceable Building Code.
- B. Compliance with the specified masonry compressive strength requirements will be demonstrated using the Prism Test Method.

1. Costs of site inspection and testing will be paid by the Owner. When tests or reports do not verify compliance, the cost of every additional test and report shall be paid by the Contractor.
- C. Test of Masonry Prisms: The Owner will test brick masonry prisms by a recognized independent testing laboratory to assure compliance with the Specifications and the governing codes.
1. Tests will be made of the following items:
 - a. At the time of the construction of the sample panel in Section 1.03 above at least 5 prisms shall be made for each type of block herein, except separate prisms are not required for block which only varies by texture.
 - b. One set of at least 5 prisms will be made for each structure, besides the structure that the sample panel is part of, or for each week in which block is laid, for each type of block involved; whichever occurs first.
 - c. Additional sets of at least 5 prisms may be required whenever, in the judgement of the Engineer, additional tests are necessary to determine the quality of the materials.
 2. The prisms shall be constructed by the Contractor in the presence of the Engineer. The same personnel who are laying the brick in the structure shall construct the prism.
 3. The masonry prisms shall be constructed and will be tested in accordance with ASTM C1314, except as modified herein. The prisms shall be composed of one complete cell using full-size bricks which are saw-cut. The minimum ratio of height to smaller width dimension shall be 1.5. The prism shall be at least 15-inches high. A minimum of 2 horizontal bed joints shall be used to form the prism. The prism shall be grouted after the required 24-hour minimum cure period, using the same grout used in the walls.
 4. Compression tests made on sets of specimens made during construction shall include 2 prisms tested at 7 Days after grouting and 3 prisms tested at 28 Days after grouting.
 5. The average compressive strength of prisms tested at 28 Days after grouting, multiplied by the appropriate correction factor as given in ASTM C1314, shall not be less than the indicated masonry compressive strength.
 6. If the compressive strengths of the prisms fail to meet or exceed the requirement, adjustments shall be made to the mix designs for the mortar, or grout, or both, as needed to produce the required strength.
- D. If the compressive strength of the prism fails to meet or exceed that required, prisms or cores shall be cut from the walls in sufficient numbers and in sufficient locations to adequately determine the strength of the walls. Those portions of the walls represented by specimens failing to meet the required compressive strength are subject to being removed and replaced.

END OF SECTION

SECTION 04 22 00 – CONCRETE UNIT MASONRY

PART 1 -- GENERAL

1.01 SUMMARY

- A. The Contractor shall provide concrete masonry and appurtenant Work, complete and in place, in accordance with the Contract Documents.

1.02 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

- A. The edition of the standards applicable to the Work shall be those editions referenced by the 2024 Ohio Building Code (IBC). If the standard is not referenced by the OBC, nor an OBC-referenced standard listed below, the edition of the standard applicable to the Work shall be the edition in effect on the date of signing and sealing of the contract specifications.

B. Reference Specifications

01 33 00	Submittal Procedures
01 35 45	Construction Waste Management
03 21 00	Reinforcement Bars
03 30 00	Cast-in-Place Concrete

C. Reference Standards

Building Code	
OBC	2024 Ohio Building Code
ASTM International (ASTM)	
ASTM A153	Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware
ASTM A615	Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement
ASTM A706	Standard Specification for Deformed and Plain Low-Alloy Steel Bars for Concrete Reinforcement
ASTM A951	Standard Specification for Steel Wire for Masonry Joint Reinforcement
ASTM C90	Standard Specification for Loadbearing Concrete Masonry Units
ASTM C109	Standard Test Method for Compressive Strength of Hydraulic Cement Mortars (Using 2-in. or [50-mm] Cube Specimens)
ASTM C140	Standard Test Methods for Sampling and Testing Concrete Masonry Units and Related Units
ASTM C144	Standard Specification for Aggregate for Masonry Mortar
ASTM C150	Standard Specification for Portland Cement
ASTM C207	Standard Specification for Hydrated Lime for Masonry Purposes
ASTM C270	Standard Specification for Mortar for Unit Masonry

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ASTM C404	Standard Specification for Aggregates for Masonry Grout
ASTM C476	Standard Specification for Grout for Masonry
ASTM C595	Standard Specification for Blended Hydraulic Cements
ASTM C618	Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete
ASTM C780	Test Method for Preconstruction and Construction Evaluation of Mortars for Plain and Reinforced Unit Masonry
ASTM C989	Standard Specification for Slag Cement for Use in Concrete and Mortars
ASTM C1019	Standard Test Method for Sampling and Testing Grout
ASTM C1093	Standard Practice for Accreditation of Testing Agencies for Masonry
ASTM C1157	Standard Performance Specification for Hydraulic Cement
ASTM C1314	Standard Test Method for Compressive Strength of Masonry Prisms
ASTM E514	Standard Test Method for Water Penetration and Leakage Through Masonry
The Masonry Society (TMS)	
TMS 402	Building Code Requirements for Masonry Structures
TMS 602	Specification for Masonry Structures

1.03 CONTRACTOR SUBMITTALS

A. Furnish submittals in accordance with Section 01 33 00 – Submittal Procedures.

1. The Contractor is responsible for all costs associated with material testing for submittals indicated herein.

B. Samples

1. If the required product is a colored and textured unit, the samples shall be colored and textured units. Submit samples of concrete masonry units illustrating colors and textures available for the Engineer to choose. Full size samples of the blocks selected shall be submitted for final approval after color selection, if requested.
2. Samples of mortar colors for color selection.

C. Concrete Masonry Unit mix design and test data

1. The Contractor shall submit concrete masonry unit mix designs and compression test data demonstrating the mix meets the specified 28-day compressive strength for the units. Compression test data shall be historical data for the identical mix, provided the data is not older than 6 months, or it shall be trial batch test data.

D. Mortar mix designs and test data

1. Mortar mix design(s) indicating type and proportions of the ingredients according to the proportion requirements of ASTM C270. Include a letter of certification or test report for each mortar material, indicating the material complies with ASTM C270.

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E. Grout

1. For each grout mix, submit mix designs, grout compressive strength tests, and certification of compliance with ASTM C476.
 - a. The Contractor shall submit grout mix designs and compression test data demonstrating the mix meets the specified 28-day compressive strength for the grout. Compression test data shall be historical data for the identical mix, provided the data is not older than 6 months, or it shall be trial batch test data.
2. Grout mix designs shall include:
 - a. Proportions for components.
 - b. Slump.
 - c. Mill tests for cement
 - d. Admixture certification with chloride ion content.
 - e. Aggregate graduation and certification
 - f. Lime certification
3. Grout compressive strength tests shall be performed in accordance with ASTM C1019.

F. Procedures

1. Cold weather construction procedures. Submit a description of procedures to be used when the ambient temperature or the temperature of masonry units falls below 40 degrees F.
2. Hot weather construction procedures. Submit a description of procedures to be used when the ambient temperature exceeds 100 degrees F or 90 degrees F with a wind velocity greater than 8 mph.
3. Review of hot and cold weather construction procedures will be for information only. The Contractor remains fully responsible for complying with the requirements of this Section and for the adequacy of procedures employed.

1.04 QUALITY ASSURANCE

- A. Applicable Standards: Concrete masonry shall conform to the OBC, TMS 402, TMS 602, and other applicable codes and standards of the governing authorities.
- B. Compliance with specified masonry compressive strength requirements will be demonstrated using the Unit Strength Method.
 1. The minimum 28-day net area compressive strength of the concrete masonry (f'm) shall be 2000 psi.
 2. The costs of preconstruction tests will be paid for by the Contractor.

3. The costs of field tests and test reports will be paid by the Owner. When tests or reports do not verify compliance, the cost of every additional test and report shall be paid by the Contractor.
- C. Cold and Hot Weather Construction: Masonry construction in cold and hot weather shall conform to the applicable requirements of the OBC and TMS 402 unless otherwise specified herein. Heat and enclosures will be the only protection method allowed for cold weather construction. No mortar additives shall be used for this purpose.
- D. Testing agencies shall comply with the requirements of ASTM C1093.

1.05 DELIVERY, STORAGE, AND HANDLING

- A. Product Storage: Cement, lime, and other cementitious materials shall be delivered and stored in dry, weather-tight sheds or enclosures, in unbroken bags, barrels, or other approved containers, plainly marked and labeled with the manufacturers' names and brands. Mortar and grout constituents shall be stored and handled in a manner that prevents the inclusion of foreign materials and damage by water or dampness. Masonry units shall be handled with care to avoid chipping and breakage, and shall be stored as directed in TMS 602. Materials stored on newly constructed floors shall be stacked in such manner that the uniformly distributed loading does not exceed 30 psf. Masonry materials shall be protected from contact with the earth and exposure to the weather and shall be kept dry and clean until used.

PART 2 -- PRODUCTS

2.01 CONCRETE MASONRY UNITS

- A. Concrete masonry units shall conform to ASTM C90. Units shall be normal weight units unless indicated otherwise.
- B. Concrete masonry units shall be 8-inch by 8-inch by 16-inch modular size, with smooth faces. Units shall be of natural gray color.
- C. Minimum compressive strength of concrete masonry units shall be 2000 psi.
- D. Bond beam, corner, lintel, sill, and other specially shaped blocks shall be provided where required or necessary. Specially shaped non-structural blocks may be constructed by saw cutting. Color and texture shall match that of adjacent units.
- E. Concrete masonry units hidden from view entirely may be natural color units the same size as other adjacent masonry units.
- F. Concrete masonry units at interior walls shall be normal weight block 8-inch by 8-inch by 16-inch modular size of natural color. All interior smooth faced concrete block, except fire-rated units, shall have recycled masonry content of at least 25 percent.

2.02 MORTAR

- A. Mortar for concrete block masonry shall conform to ASTM C270 for cement-lime Type S, with a minimum 28 Day compressive strength of 1800 psi.
- B. Portland cement in mortar shall be Type I or II, low alkali, conforming to ASTM C150.

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- C. Aggregate for mortar shall conform to ASTM C144.
- D. Hydrated lime for mortar shall conform to ASTM C207 Type S.
- E. Water for mortar shall be clean potable water.
- F. The weight of mineral oxide or carbon black pigments added to the project-site prepared mortar shall comply with TMS 602 Article 2.6 A.

2.03 GROUT

- A. Grout shall be coarse grout conforming to ASTM C476 Table 1 and TMS 602 Article 2.2 with a minimum 28 Day compressive strength of 2000 psi. Where the grout space is less than 4-inches, coarse aggregate shall be omitted.
- B. Portland cement in grout shall be Type I or II, low alkali, conforming to ASTM C150.
- C. Aggregate for grout shall conform to ASTM C404.
- D. Hydrated lime in grout shall conform to ASTM C207 Type S.
- E. Water for grout shall be clear potable water.
- F. Admixture for grout shall be Sika Grout Aid by Sika Corporation, Type II, BASF Pozzoloth, normal, or equal. Admixtures shall be used in accordance with the manufacturer's published recommendations.

2.04 OTHER MATERIALS

- A. Reinforcing steel shall be deformed bars conforming to ASTM A615 and Section 03 21 00 Reinforcement Bars, and 03 30 00 Cast-in-Place Concrete.
- B. Reinforcing steel positioners shall be hot-dipped galvanized wire, designed specifically for properly locating and holding in place reinforcement. Reinforcing steel positioners for vertical bars shall be shop fabricated to be set firmly recessed within the block core and to maintain proper bar location during mortar and grouting operations, Core Lock by Wire-Bond, Pro Block by Wire-Bond, or equal.
- C. Joint reinforcing
 - 1. Joint reinforcing shall conform to ASTM A951.
 - 2. The minimum size of longitudinal and cross wires shall be W1.7 (9-gauge). Longitudinal wires shall be deformed. Maximum spacing of cross wires in ladder-type and points of connection of cross wires to longitudinal wire of truss-type shall be 16-inches.
 - 3. Joint reinforcement shall be hot-dip galvanized after fabrication per ASTM A153.
 - 4. Corners and wall intersections shall use prefabricated corners and tees.
 - 5. Joint reinforcement shall be continuous or
 - a. lapped by 54 wire diameters in a grouted cell, or

- b. lapped by 75 wire diameters in a mortared bed joint, or
 - c. in alternate bed joints of running bond masonry, lapped a distance not less than 54 diameters plus twice the spacing of the bed joints.
- D. Masonry cleaner shall be a non-acidic cleaner, SafEtch by Prosoco, Inc., or equal.

PART 3 -- EXECUTION

3.01 GENERAL

- A. Measurements for mortar and grout shall be accurately made. Shovel measurements are not acceptable. Mortar proportions shall be accurately controlled and maintained.
- B. Work shall be performed in accordance with the provisions of TMS 402 and TMS 602, the OBC and the local codes for reinforced concrete masonry.
- C. The Contractor shall set or embed anchors, bolts, reglets, sleeves, conduits, and other items as required.
- D. Block cutting shall be by machine.
- E. Masonry units shall be supported off the ground and shall be covered to protect them from rain. Only clean, dry, uncracked units shall be incorporated.
- F. Reinforcing steel shall be cleaned of loose rust and scale, oil, dirt, paint, laitance, or other substances that may be detrimental to or reduce bonding of the steel and concrete.
- G. Immediately before starting Work, concrete upon which the masonry will be laid shall be cleaned with water under pressure.
- H. Full mortar joint for first course shall be provided.
- I. Units shall be installed tightly against adjacent units to assure good mortar bond.
- J. Equipment for mixing and transporting the mortar and grout shall be clean and free from set mortar, dirt, or other foreign matter.

3.02 EXTERME WEATHER CONSTRUCTION

- A. Cold weather construction shall be per the more stringent of the submitted cold weather procedures, TMS 602, and local Code requirements.
- B. Hot weather construction shall be per the more stringent of the submitted hot weather procedures, TMS 602, and local Code requirements.

3.03 MORTAR MIXING AND RETEMPERING

- A. Mortar shall be mixed by placing 1/2 of the water and sand in the operating mixer, after which the cement, lime, and remainder of the sand and water shall be added. After ingredients are in the mixer, they shall be mechanically mixed between 3 and 5 minutes in a mechanical batch mixer.

- B. Retempering shall be done on the mortar board by adding water within a basin formed within the mortar, and the mortar reworked into the water.
- C. Mortar that is not used within one hour shall be discarded.

3.04 ERECTION OF CONCRETE MASONRY UNITS

- A. Masonry Work shall be erected in plane, plumb, level, straight and true to dimensions, and be executed in accordance with acceptable practices of the trade and the tolerances of TMS 602.
- B. Unless indicated otherwise, masonry shall be laid up in straight uniform courses with running bond.
- C. Masonry shall be erected to preserve the unobstructed vertical continuity of the cells measuring not less than 3 inches by 3 inches in cross-section. Walls and cross webs shall be full bedded in mortar. Head (or end) joints shall be solidly filled with mortar for a distance in from the face of the wall or unit not less than the thickness of the longitudinal face shells.

3.05 JOINTS

- A. Vertical and horizontal joints shall be uniform and approximately 3/8 inch thick. Bed joints shall not exceed 5/8-inch thickness.
- B. Interior or exterior non-exposed masonry and masonry behind plaster shall have flush joints.

3.06 CLEANOUTS

- A. Cleanout openings shall be provided at the bottoms of cells to be filled at each lift or pour of grout where such lift or pour is over 4 feet in height. Any overhanging mortar or other obstructions or debris shall be removed from the insides of such cell walls. The cleanouts shall be sealed before grouting and after inspection. Cleanout openings shall match the finished wall in exposed masonry.

3.07 REINFORCEMENT

- A. Deep cut bond beam blocks shall be used where horizontal reinforcing steel is embedded. H-block bond beams may be used at locations other than openings.
- B. Knock-out openings shall have no steel or joint reinforcing running through the opening. Head, jambs, and sill blocks shall be used to provide an even finish surface to install windows when blocks are removed. Joints at heads, jambs, and sills shall be stacked and continuous.
- C. Vertical reinforcement shall be held in position at top and bottom and at intervals not exceeding 112 diameters of the reinforcement.

3.08 GROUTING

- A. Cells containing reinforcing and bond beam spaces shall be filled solidly with grout unless indicated otherwise. Grouting shall not be started until the wall has cured for 24 hours. Grout shall not be poured in more than 5-ft lifts.

- B. Grout shall be consolidated at time of pouring by puddling or vibrating. If the grouting operation has been stopped for one hour or longer, horizontal construction joints shall be formed by stopping the grout pour 1-1/2 inches below the top of the uppermost unit.

3.09 PIPE OR CONDUITS EMBEDDED IN MASONRY

- A. Pipes, conduits, and sleeves passing vertically or horizontally through the masonry shall not be placed closer than 3 diameters on center, nor shall they impair the strength of the construction. Pipes, conduits, and sleeves passing vertically shall not be placed in the same cell as the vertical reinforcing. Pipes, conduits, and sleeves passing horizontally shall not be placed in a bond beam.
- B. Maximum area of vertical conduits, pipes, or sleeves placed in masonry columns or pilasters shall not displace more than 2 percent of the net cross section.

3.10 PROTECTION

- A. Wall surfaces shall be protected from droppings of mortar or grout during construction.

3.11 SITE QUALITY CONTROL

- A. Inspection and Testing: Whenever required under the provisions of the Building Code or these contract documents, Work hereunder will be subject to inspection by the Special Inspector. Special inspection will be performed as required by the Drawings, TMS 402/602, Level 2 Quality Assurance and the enforceable Building Code.
- B. Compliance with the specified masonry compressive strength requirements will be demonstrated using the Unit Strength Method.
 - 1. Costs of site inspection and testing will be paid by the Owner. When tests or reports do not verify compliance, the cost of every additional test and report shall be paid by the Contractor.
- C. Unit Strength Method Testing:
 - 1. The Special Inspector in conjunction with a recognized testing laboratory will conduct the following testing.
 - 2. Masonry Units: Concrete block masonry units will be sampled and tested in accordance with ASTM C140.
 - a. Tests will be made of the following items:
 - 1) Prior to installation, at least 6 masonry units shall be tested for each type of block herein, except separate tests are not required for block which only varies by texture.
 - 2) At any change in materials during construction, at least 6 masonry units shall be tested.
 - 3) Additional sets of at least 6 masonry units shall be tested whenever, in the judgment of the Engineer, additional tests are necessary to determine the quality of the materials.

- 4) The Contractor shall submit a letter of certification from the CMU Supplier at the time of, or prior to, delivery of the materials to the Site that the materials used in construction are representative of the materials used during pre-installation testing.
3. Mortar: The Special Inspector will verify the following by observation:
 - a. The method of measuring material quantities for the mortar used in construction accurately maintains the required proportions.
 - b. The individual mortar materials being used are those approved for the project.
4. Grout: The Special Inspector will sample and test grout to confirm compliance with the Specifications and the governing Codes.
 - a. Testing will be done by a recognized testing laboratory approved by the Engineer. Test reports shall be submitted to the Engineer.
 - b. Grout and masonry units required to construct the test molds shall be supplied by the Contractor at no additional cost to the Owner and shall match the materials being used in construction.
 - c. Grout will be tested in accordance with ASTM C1019. Each sample will be tested for temperature, slump, and compressive strength.
 - d. Tests shall be taken at the following times:
 - 1) Prior to installation, 1 sample of grout will be tested.
 - 2) At any change in materials or job conditions, 2 samples of grout will be tested.
 - 3) Additional samples and tests may be required whenever, in the judgment of the Engineer, additional tests are necessary to assure the quality of the materials.
5. Samples shall be stored in a moist environment until tested, unless directed otherwise by the Engineer or the testing laboratory.

3.12 FINISHING AND CLEANING

- A. Masonry shall not be wet-finished unless exposed to extreme hot weather or hot wind and then only by using a nozzle-regulated fog spray sufficient only to dampen the face but not of such quantity to cause water to flow down over the masonry.
- B. Finish masonry shall be cleaned and pointed in a manner satisfactory to the Engineer.
- C. Interior and exterior colored masonry Work exposed to view shall be cleaned by whip light sandblasting to remove stains and other imperfections.
- D. Exposed masonry surfaces of openings and window and door openings such as sills, heads, and jambs shall be finish block surfaces, not formed surfaces, unless indicated otherwise. Closed bottom bond beam blocks shall be used at heads and sills. Pour holes may be used at the sill under window frame and where approved by the Engineer.

END OF SECTION

SECTION 05 05 19 – POST-INSTALLED CONCRETE ANCHORS

PART 1 -- GENERAL

1.01 SUMMARY

- A. Provide post-installed anchors and appurtenances, complete and in place, as indicated in accordance with the Contract documents.
- B. Unless otherwise indicated, drilled concrete anchors shall be adhesive anchors.
- C. Section Includes:
 - 1. Adhesive anchors
 - 2. Expansion anchors
 - 3. Screw anchors
 - 4. Undercut anchors (dynamic loading)

1.02 REFERENCE SPECIFICATIONS, CODES AND STANDARDS

A. Definitions

- 1. Epoxy anchors are considered to be adhesive anchors.
- 2. Expansion anchors, screw anchors, and undercut anchors are considered to be mechanical anchors.

B. Reference Specifications

01 33 00	Submittal Procedures
01 33 17	Structural Design, Support and Anchorage
03 01 00	Maintenance of Concrete
03 21 00	Reinforcement Bars
03 30 00	Cast-in-Place Concrete
05 50 00	Metal Fabrications

C. Reference Standards

- 1. The edition of the standards applicable to the Work shall be the edition referenced by the 2024 Ohio Building Code (OBC). If the standard is not referenced by the OBC-referenced standard listed below, the edition of the standard applicable to the Work shall be the edition in effect on the date of signing and sealing of the contract specifications.

Building Code	
OBC	Ohio Building Code
American Concrete Institute (ACI)	
ACI 318	Building Code Requirements for Structural Concrete and Commentary
ACI 350	Code Requirements for Environmental Engineering Concrete Structures and Commentary
ACI 355.2	Qualification of Post Installed Mechanical Anchors in Concrete and Commentary
ACI 355.4	Qualification for Post-Installed Adhesive Anchors in Concrete and Commentary
American Society of Civil Engineers (ASCE)	
ASCE 7	ASCE/SEI 7 - Minimum Design Loads for Buildings and Other Structures
International Code Council (ICC)	
ICC ES AC193	Mechanical Anchors in Concrete Elements
ICC ES AC308	Post Installed Adhesive Anchors in Concrete Elements
NSF International (NSF)	
NSF/ANSI 61	Drinking Water System Components - Health Effects

1.03 SUBMITTALS

- A. Furnish submittals in accordance with Section 01 33 00 – Submittal Procedures.
- B. Submit the following:
 1. Product data and technical information
 2. Safety Data Sheets (SDS) for adhesives
 3. Manufacturer's literature containing installation instructions and appropriate uses for each type of post-installed anchor and location of use
 4. Current International Code Council Evaluation Service (ICC-ES) or International Association of Plumbing and Mechanical Officials Uniform Evaluation Service (IAPMO-UES) Evaluation Reports
 5. Certification for each installer demonstrating that they have been qualified in accordance with the Quality Assurance requirements below
- C. No substitution for the indicated anchors will be considered unless accompanied with an ICC-ES or IAPMO-UES report verifying strength and material equivalency.
- D. Complete structural calculations and anchorage details shall be prepared and submitted by the Contractor for all anchors and anchor groups that are shown but not completely detailed (type, size, location, spacing and embedment) on the Contract Documents. Calculations and anchorage details shall be completed and submitted in accordance with Section 01 33 17 – Structural Design, Support and Anchorage.

1. Where adhesive anchors are used for structural applications (such as dowels between new and existing concrete) and an embedment depth is not shown on the contract documents, the anchor shall be installed in accordance with Method 1 or Method 2 below:
 - a. Method 1: The minimum depth of embedment shall be greater than or equal to the development length (l_d) determined in accordance with ACI 318 or ACI 350, as applicable, for a cast in place reinforcing bar of the same diameter and grade, unless it can be shown by calculation that the anchor spacing and edge distance is sufficient to develop the tensile strength of the anchor in a lesser depth of embedment.
 - b. Method 2: Adhesive anchors in concrete that cannot develop the tensile capacity of the steel element may be used to transfer forces, provided that:
 - 1) For new structures, the anchor is designed in accordance with ACI 318 or ACI 350, as applicable.

1.04 QUALITY ASSURANCE

- A. Special inspection for all post-installed anchor installations shall be provided:
 1. As recommended or required by the ICC-ES or IAPMO-UES report.
 2. As required by the enforceable building code.
 3. As otherwise indicated in the Contract Documents.
- B. The most stringent of the above requirements shall be used. The cost of Special Inspection of post-installed anchors shall be paid for by the Owner.
- C. Before installing adhesive anchors in the Work, anchor installers shall be trained and qualified at the Site by the manufacturer's representative. Training and qualification for each installer shall include at least:
 1. Hole drilling procedure, hole preparation and cleaning techniques, adhesive injection technique and dispenser training/maintenance, rebar dowel preparation and installation, and proof loading if required.
 2. Each installer shall be re-qualified every 6 months for the duration of the project by the same qualifying procedure.
- D. Before installing mechanical anchors in the Work, anchor installers shall be trained and qualified at the Site by the manufacturer's representative. Training and qualification for each installer shall include at least:
 1. Hole drilling procedure, hole preparation and cleaning techniques, and torquing.
 2. Each installer shall be re-qualified every 6 months for the duration of the project by the same qualifying procedure.
- E. Defective anchors noted by the Special Inspector shall be replaced and re-installed by the Contractor without any additional compensation.

1.05 DELIVERY, STORAGE, AND HANDLING

- A. Deliver products to job site in manufacturer's or distributor's packaging undamaged, complete with installation instructions.
- B. Protect and handle materials in accordance with manufacturer's recommendations to prevent damage or deterioration.
- C. Anchoring adhesives shall be stored at temperatures prescribed by the manufacturer and must not be used beyond the expiration date.

1.06 SITE CONDITIONS

- A. Post-installed anchors shall be installed in concrete having a minimum age of 21 days at time of anchor installation.
- B. The anchor or fastener coating, plating, or steel type must provide suitable corrosion resistance for the environment in which the anchor or fastener is installed. Anchors, nuts, and washers in the locations listed below shall be fabricated from type 316 or 304 stainless steel:
 - 1. buried locations
 - 2. submerged locations
 - 3. locations subject to seasonal or occasional flooding
 - 4. inside hydraulic structures below the top of the structure
 - 5. inside buried vaults, manholes, and structures that do not drain through a gravity sewer or to a sump with a pump
 - 6. chemical handling areas
 - 7. inside trenches, containment walls, and curbed areas
 - 8. locations indicated or designated by the Engineer to be provided with stainless steel anchors.

PART 2 -- PRODUCTS

2.01 ADHESIVE ANCHORS

- A. General
 - 1. The adhesive anchor system shall consist of: 1) adhesive product; and 2) threaded rod or reinforcing bar insert. The complete system shall be compatible as required by the adhesive manufacturer.
 - 2. Adhesives shall be injectable, two-component, cartridge-type systems dispensed and mixed through a static mixing nozzle supplied by the manufacturer.
 - 3. The evaluation report issued by ICC-ES or IAPMO-UES shall state the acceptability of the adhesive anchor for the intended purpose and location.

4. Adhesive anchors shall be permitted when regular ambient temperatures are consistent with manufacturer's recommendation for long and short term temperatures.
5. Adhesive anchors shall not be used where anchors are subject to vibration or fire.
6. Adhesive anchors shall not be used in overhead applications.
7. Where required, adhesive shall be capable of being used in submerged applications once cured.
8. Adhesive shall meet the requirements of NSF/ANSI 61.

B. Adhesive Anchors in Concrete

1. Threaded rod inserts shall meet the requirements of Section 05 50 00 - Metal Fabrications.
2. Reinforcing dowel inserts shall meet the material requirements of Section 03 21 00 – Reinforcement Bars and 03 30 00 – Cast-in-Place Concrete.
3. Adhesive for use in concrete adhesive anchors shall be certified for use in accordance with ICC-ES AC308.
4. Where not detailed on the drawings, adhesive anchors shall be designed in accordance with ACI 318 as amended by the specific design provisions of ICC-ES AC308.
5. Adhesive anchors shall have an evaluation report issued by ICC-ES or IAPMO-UES and have been tested and qualified for performance in cracked and uncracked concrete in accordance with ICC-ES AC308 and ACI 355.4. Adhesive anchors to be used for structures, nonbuilding structures and/or nonstructural components assigned to Seismic Design Categories C through F shall have been tested and qualified for earthquake loading performance in cracked and uncracked concrete in accordance with ICC-ES AC308 and ACI 355.4.
6. Adhesive anchors for concrete shall be Pure110+ by Powers Fasteners, HIT-RE 500 V3 by Hilti or SET-XP by Simpson Strong-Tie, or equal.

2.02 EXPANSION ANCHORS

A. General

1. Expansion anchors are post-installed torque-controlled mechanical expansion anchors used to resist structural loads.
2. Expansion anchors shall be an imperial sized, threaded stud with an integral cone expander, expansion clip, nut and washer.
3. Lead caulking anchors will not be permitted.
4. Non-embedded buried or submerged anchors shall be fabricated from stainless steel.
5. The evaluation report issued by ICC-ES or IAPMO-UES shall state the acceptability of the expansion anchor for the intended purpose and location.

6. Anchors subjected to dynamic or vibratory loading shall be suitable for the intended loading and location as indicated in the manufacturer's technical product data.

B. Expansion Anchors for Concrete

1. Anchors shall be designed in accordance with ACI 318, which requires post-installed mechanical anchors to be qualified according to ACI 355.2.
2. Anchors shall have an evaluation report issued by ICC-ES or IAPMO-UES and have been tested and qualified for performance in cracked and uncracked concrete in accordance with ICC-ES AC193 and ACI 355.2. Anchors to be used for structures, nonbuilding structures and/or nonstructural components assigned to Seismic Design Categories C through F shall have been tested and qualified for earthquake loading performance in cracked and uncracked concrete in accordance with ICC-ES AC193 and ACI 355.2.
3. Expansion anchors shall be Strong-Bolt 2 by Simpson Strong-Tie, Kwik-Bolt TZ2 by Hilti, Power-Stud+ SD1 by Powers Fasteners, or equal.

2.03 SCREW ANCHORS

A. General

1. Screw anchors used in exterior and corrosive environments shall be fabricated from stainless steel.
2. The evaluation report issued by ICC-ES or IAPMO-UES shall state the acceptability of the screw anchor for the intended purpose and location.
3. Anchors subjected to dynamic or vibratory loading shall be suitable for the intended loading and location as indicated in the manufacturer's technical product data.

B. Screw Anchors for Concrete

1. Anchors shall be designed in accordance with ACI 318 as amended by the specific design provisions of ICC-ES AC193.
2. Anchors shall have an evaluation report issued by ICC-ES or IAPMO-UES and have been tested and qualified for performance in cracked and uncracked concrete in accordance with ICC-ES AC193.
3. Screw anchors for concrete shall be Titen HD by Simpson Strong-Tie, Kwik HUS-EZ (KH-EZ) by Hilti, or equal.

2.04 UNDERCUT ANCHORS

A. General

1. Undercut anchors are post-installed mechanical anchors that require pre-drilling and a special undercut notch configuration cut into the concrete before installation.
2. Self-undercutting anchors are post-installed torque-controlled mechanical anchors that cut their own undercut notch by application of a setting torque that forces a sleeve over a cone.

3. The evaluation report issued by ICC-ES or IAPMO-UES shall state the acceptability of the undercut anchor for the intended purpose and location.
4. Anchors subjected to dynamic or vibratory loading shall be suitable for the intended loading and location as indicated in the manufacturer's technical product data.
5. Undercut anchors used in exterior and corrosive environments shall be fabricated from stainless steel.

B. Undercut Anchors for Concrete

1. Anchors shall be designed in accordance with ACI 318 as amended by the specific design provisions of ICC-ES AC193.
2. Anchors shall have an evaluation report issued by ICC-ES or IAPMO-UES and have been tested and qualified for performance in cracked and uncracked concrete in accordance with ACI 355.2 and ICC-ES AC193.
3. Undercut anchors for concrete shall be HDA by Hilti, Atomic+ by Powers Fasteners, or equal.

PART 3 -- EXECUTION

3.01 INSTALLATION REQUIREMENTS

- A. Post-installed anchors shall be installed in strict accordance with the manufacturer's instructions, the ICC-ES or IAPMO-UES report, and project specific design requirements indicated on the Contract Documents or in the design calculations provided by the Contractor.
- B. Where holes are drilled in concrete, holes shall be accurately and squarely drilled, and the holes shall be cleaned in accordance with the manufacturer's recommendations.
- C. Post-installed anchors shall not be installed until the concrete has reached the required age of 21 days or per manufacturer's requirements, whichever is longer.
- D. Acceptable installation and performance temperature ranges shall be verified with manufacturer's literature prior to installation. Minimum substrate temperatures shall be maintained during the full curing period as required by the manufacturer.
- E. Adhesive anchors shall not be loaded until the adhesive has reached its indicated strength in accordance with the manufacturer's instructions.
- F. The Contractor shall locate existing items and identify the position of reinforcing steel and other embedded items prior to drilling holes. Care shall be exercised in drilling to avoid damaging existing reinforcing or embedded items. The location of drilled holes shall be adjusted to avoid drilling through or cutting any existing reinforcing bars or embedded items. Notify the Engineer if reinforcing steel or other embedded items are encountered during drilling. Take precautions as necessary to avoid damaging prestressing tendons, electrical and communications conduit, and piping.
- G. Core drilling of holes is not allowed.
- H. Bending of and welding to post installed anchors is not allowed.

- I. Identification of reinforcing steel and/or embedded items, relocation of drilled holes and adjustments or modifications to anchored or fastened items shall be considered part of the Work and shall be provided at no additional cost to the Owner.
- J. All abandoned drilled holes shall be repaired in accordance with Section 03 01 00 – Maintenance of Concrete at no additional cost to the Owner.

END OF SECTION

SECTION 05 12 00 – STRUCTURAL STEEL FRAMING

PART 1 -- GENERAL

1.01 SUMMARY

- A. The Contractor shall provide structural steel framing and appurtenant metal parts required for permanent connection of the structural steel system, complete and in place, in accordance with the Contract Documents.
- B. The design, fabrication, and erection of structural steel elements in buildings and non-building structures, and elements thereof, shall be in accordance with the 2024 Ohio Building Code (OBC) and AISC 360.

1.02 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

A. Reference Specifications

01 33 00	Submittal Procedures
05 50 00	Metal Fabrications
09 96 00	High-Performance Coatings

- B. The edition of the standards applicable to the Work shall be those editions referenced by the 2024 Ohio Building Code (OBC). If the standard is not referenced by the OBC, nor an IBC-referenced standard listed below, the edition of the standard applicable to the Work shall be the edition in effect on the date of signing and sealing of the contract specifications.

C. Reference Standards

American Institute of Steel Construction (AISC)	
AISC 303	Code of Standard Practice for Steel Buildings and Bridges
AISC 360	Specification for Structural Steel Buildings
ASTM International (ASTM)	
ASTM A36	Standard Specification for Carbon Structural Steel
ASTM A53	Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
ASTM A193	Standard Specification for Alloy-Steel and Stainless Steel Bolting for High Temperature or High Pressure Service and Other Special Purpose Applications
ASTM A194	Standard Specification for Carbon and Alloy Steel Nuts for Bolts for High Pressure or High Temperature Service, or Both
ASTM A307	Standard Specification for Carbon Steel Bolts, Studs, and Threaded Rod 60000 PSI Tensile Strength
ASTM A500	Standard Specification for Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes
ASTM A572	Standard Specification for High-Strength Low-Alloy Columbium-Vanadium Structural Steel
ASTM A992	Standard Specification for Structural Steel Shapes

ASTM F3125	Standard Specification for High Strength Structural Bolts, Steel and Alloy Steel, Heat Treated, 120 ksi and 150 ksi Minimum Tensile Strength
American Welding Society (AWS)	
AWS B1.5	Standard for the Qualification of Welding Inspectors
AWS D1.1	Structural Welding Code – Steel
AWS QC1	Specification for AWS Certification of Welding Inspectors
International Code Council (ICC)	
OBC	2024 Ohio Building Code
Research Council on Structural Connections (RCSC)	
RCSC	Specification for Structural Joints Using High-Strength Bolts

1.03 CONTRACTOR SUBMITTALS

- A. Submit in accordance with Section 01 33 00 – Submittal Procedures.
- B. Shop Drawings, including fabrication and erection drawings for all Work, shall conform to AISC recommendations and specifications and shall show all holes, etc. required for other work. Drawings shall include complete details showing members and their connections, anchor bolt layouts, schedules for fabrication procedures, and diagrams showing the sequence of erection.
- C. Testing laboratory certifications for shop and field welders shall be submitted directly to the Engineer with copies to the Contractor and others as required.
- D. Contractor's Statement of Responsibility, as required by the OBC Section 1704.4
- E. Charpy V-notch impact test results for heavy section hot-rolled shapes.
- F. Certifications for consumables for welding.
- G. Quality Control inspection reports.

1.04 QUALITY ASSURANCE

- A. Quality Assurance shall be provided as required by the OBC and AISC 360.
 - 1. Special Inspections and Tests requirements indicated in the OBC Chapter 17, and Quality Assurance requirements indicated in AISC 360 Chapter N, will be provided by and paid for by the Owner.
 - 2. Structural Observations, if required by the Building Official or requested by the Owner, will be provided by and paid for by the Owner.
 - 3. Contractor Responsibility requirements indicated in the OBC Chapter 17 shall be provided by and paid for by the Contractor.
- B. The Contractor shall be aware of all Quality Assurance requirements, and shall provide advance notice and full access to the Owner and Engineer to conduct the inspections, tests, and observations.

1. For inspections and tests at locations away from the project site, a minimum of 14 days' notice shall be provided in writing.
 2. For inspections, tests and observations at the project site, a minimum of 7 days' notice shall be provided in writing.
 3. The Contractor shall provide safe access, including fall protection equipment, to all locations necessary to conduct the inspections, tests, and observations.
- C. The Contractor shall supply material for testing at no cost to the Owner and shall assist the Engineer in obtaining material for test samples.
- D. The Contractor shall correct or repair all defective Work. All costs associated with corrections, repairs, and retesting shall be paid for by the Contractor.
- E. Refer to PART 2 for Quality Control requirements.

PART 2 -- PRODUCTS

2.01 MATERIALS

A. Structural steel

ASTM A992	Wide Flange Shapes
ASTM A36	Other Shapes, Plates, Bars
ASTM A53, Type E or S, Grade B standard weight unless noted otherwise	Pipe, Pipe Columns, Bollards
ASTM A500 Grade B	HSS

B. Heavy Section Hot-Rolled Shapes

1. Hot-rolled shapes with flange thickness equal to or greater than 1 1/2 inch shall have a minimum Charpy V-notch toughness of 20 ft-bl at 70 degrees F, tested in the alternate core location as described in ASTM A6 Supplementary Requirement S30.

C. Welds

1. Seismic Force Resisting Systems

- a. Refer to the General Structural Contract Drawings for the listing of seismic force resisting systems for each Facility.
- b. Welds shall conform to the requirements of AISC 358.
- c. Welds used in members and connections in seismic force resisting systems shall be made with filler metals meeting the requirements specified in clauses 6.1, 6.2 and 6.3 of AWS D1.8.

2. Other filler metals and fluxes shall conform to one of the AWS specifications listed in AISC 360 Section A3.5.

D. Bolts for connections shall be ASTM F3125 Grade A325, unless indicated otherwise.

STRUCTURAL STEEL FRAMING

1. ASTM F3125 Grade A490 bolts shall be used where indicated.
 2. Use of ASTM F3125 Grade F1852 or Grade F2280 Twist-Off/Tension-Control bolts in place of Grade A325 or Grade A490 Heavy Hex Head bolts, respectively, is subject to Engineer approval.
- E. Bolts used to connect dissimilar metals shall be ASTM A193 and A194, Type 316 stainless steel.
- F. Welded anchor studs shall be headed concrete anchor studs (HAS), or deformed bar anchors (DBA), or threaded studs (TAS), as indicated on the Drawings and as supplied by Nelson Stud Welding Company, Omark Industries, KSM Fastening Systems Division, or equal.
- G. Structural steel shall be cleaned and coated in accordance with Section 09 96 00 – High-Performance Coatings.
- H. Steel members in contact with aluminum shall be galvanized per Section 05 50 00 – Metal Fabrications, unless indicated otherwise.
- I. Structural members shall be furnished full length without splices unless otherwise indicated or approved by the Engineer.

2.02 QUALITY CONTROL

- A. Quality Control shall be provided as required by AISC 360.
1. Quality Control requirements indicated in AISC 360 Chapter N shall be provided by and paid for by the Contractor.

PART 3 -- EXECUTION

3.01 MEASUREMENT

- A. The Contractor shall verify dimensions and shall make any field measurements necessary and shall be fully responsible for accuracy and layout of Work. The Contractor shall review the Drawings, and any discrepancies shall be reported to the Engineer for clarification prior to starting fabrication.

3.02 FABRICATION AND ERECTION

- A. Structural steel shall be fabricated and erected in accordance with the Drawings, AISC Specifications, AWS Standards, and the Shop Drawings.
- B. Materials shall be properly marked and match-marked for field assembly.
- C. Where finishing is required, assembly shall be completed including bolting and welding of units, before start of finishing operations.

3.03 BOLTED CONSTRUCTION

- A. The Contractor shall comply with the requirements of the AISC and RCSC specifications applicable to bolted connections.

- B. Surfaces for slip-critical connections shall be prepared in accordance with RCSC specifications.

3.04 WELDED CONSTRUCTION

- A. The Contractor shall comply with the AISC specifications, AWS D1.1 and AWS D1.8 for procedures, appearance, and quality of welds and welders, and methods used in correcting Defective Work. Welded architectural metal that is exposed to view shall have welds ground smooth. Shielded metal arc welding method or gas metal arc welding methods shall be used for welding structural steel.
- B. Unless otherwise indicated, butt and bevel welds shall be complete penetration.

3.05 HOLES FOR OTHER WORK

- A. Holes shall be provided as necessary or as indicated for securing other Work to structural steel framing, and for the passage of other Work through steel framing members. No torch cut holes will be permitted.

3.06 SHOP PAINT PRIMER

- A. Shop paint primer shall be applied in accordance with Section 09 96 00 – High-Performance Coatings. Omit shop-applied primer at field weld locations, for the portion of a member to be embedded in concrete, and where galvanizing with no further coating is required.

3.07 PRODUCT DELIVERY, STORAGE, AND HANDLING

- A. Structural members shall be loaded in such a manner that they may be transported and unloaded without being excessively stressed, deformed, or otherwise damaged.
- B. Structural steel members and packaged materials shall be protected from corrosion and deterioration. Material shall be stored in a dry area and shall not be placed in direct contact with the ground. Materials shall not be placed on the structure in a manner that might cause distortion or damage to the members or the supporting structures. Repair or replace damaged materials or structures as directed.

3.08 ERECTION

- A. The Contractor shall comply with the AISC Specifications and Code of Standard Practice, and with indicated requirements.
- B. High-strength bolts shall be installed in accordance with the RCSC Specification. The connections shall be the slip-critical, unless indicated otherwise.
- C. Anchor rods and other connectors required for securing structural steel to in-place Work and templates and other devices for presetting bolts and other anchors to accurate locations shall be furnished by the Contractor.
- D. The Contractor shall be responsible for designing and installing any temporary bracing required for the safe erection of structural steel members.

3.09 SETTING BASES AND BEARING PLATES

- A. Prior to the placement of non-shrink grout beneath base and bearing plates, the bottom surface of the plates shall be cleaned of all bond-reducing materials, and concrete and masonry bearing surface shall also be cleaned of all bond-reducing materials and be roughened to improve bonding.
- B. Loose and attached baseplates and bearing plates for structural members shall be set on wedges, leveling nuts, or other adjustable devices.
- C. Anchor rods shall be tightened after the supported members have been positioned and plumbed and the non-shrink grout has attained its indicated strength.
- D. Baseplates shall be grouted with non-shrink grout to assure full uniform bearing. Grouting shall be done prior to placing loads on the structure.

3.10 FIELD ASSEMBLY

- A. Structural frames shall be set accurately to the lines and elevations indicated. The various members shall be aligned and adjusted to form a part of a complete frame or structure before permanently fastening. Bearing surfaces and other surfaces that will be in permanent contact shall be cleaned before assembly. Necessary adjustments to compensate for discrepancies in elevations and alignments shall be performed.
- B. Individual members of the structure shall be leveled and plumbed within AISC tolerances.
- C. Required leveling and plumbing measurements shall be established on the mean operating temperature of the structure.

3.11 MISFITS AT BOLTED CONNECTIONS

- A. Where misfits in bolting are encountered, the Engineer shall be immediately notified. The Contractor shall submit a method to remedy the misfit for review by the Engineer. The Engineer will determine whether the remedy is acceptable or if the member must be refabricated.
- B. Incorrectly sized or misaligned holes in members shall not be enlarged by burning or by the use of drift pins.
- C. Correction of misfits is part of the Work.

3.12 GAS CUTTING

- A. Gas cutting torches shall not be used in the field for correcting fabrication errors in the structural framing, except when approved by the Engineer. Gas-cut sections shall be finished equal to a sheared appearance.

3.13 TOUCH-UP PAINTING

- A. Immediately after erection, field welds, bolted connections, and abraded areas shall be cleaned of the shop paint primer. Touch-up paint primer applied by brush or spray shall be the same thickness and material as used for the shop coat. Galvanized surfaces that have been field welded or damaged shall be repaired in accordance with Section 05 50 00 Metal Fabrications.

- B. Finish coating of structural steel shall be as indicated in Section 09 96 00 – High-Performance Coatings.

END OF SECTION

SECTION 05 30 00 – METAL DECKING

PART 1 -- GENERAL

1.01 SUMMARY

- A. The Contractor shall provide steel decking and accessory items, complete and in place, in accordance with the Contract Documents.

1.02 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

A. Reference Specifications

01 33 00	Submittal Procedures
05 50 00	Metal Fabrications
05 12 00	Structural Steel Framing
09 96 00	High-Performance Coatings
13 34 19	Pre-Engineered Metal Buildings

- B. The edition of the standards applicable to the Work shall be those editions referenced by the 2024 Ohio Building Code (OBC). If the standard is not referenced by the OBC, nor an OBC-referenced standard listed below, the edition of the standard applicable to the Work shall be the edition in effect on the date of signing and sealing of the contract specifications.

C. Reference Standards

American Iron and Steel Institute (AISI)	
AISI S100	North American Specifications for the Design of Cold - Formed Steel Structural Members
ASTM International (ASTM)	
ASTM A653	Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy Coated (Galvanealed) by the Hot-Dip Process
American Welding Society (AWS)	
AWS D1.3	Structural Welding Code-Sheet Steel
International Association of Plumbing and Mechanical Officials (IAPMO)	
IAPMO-UES	Evaluation Reports for each type of steel decking used in the Work
International Code Council (ICC)	
ICC-ES	Evaluation Reports for each type of steel decking used in the Work
Steel Deck Institute (SDI)	
SDI C	Standard for Composite Steel Floor Deck - Slabs
SDI RD	Standard for Steel Roof Deck
SDI NC	Standard for Noncomposite Steel Floor Deck
SDI QA/QC	Standard for Quality Control and Quality Assurance for Installation of Steel Deck

1.03 CONTRACTOR SUBMITTALS

- A. Furnish submittals in accordance with Section 01 33 00 – Submittal Procedures.
- B. Prior to the commencement of any Work, the Contractor shall submit an affidavit furnished by the deck manufacturer certifying the yield strength, gauge and section properties, and diaphragm shear values for the steel deck using the welding pattern and/or shear capacity indicated. Failure to conform to this requirement shall be justification for rejection of the material.
- C. Submit a layout drawing showing the location of deck sheets, end laps, side laps, types and locations of welds and details of accessories.
- D. Submit an ICC-ES or IAPMO-UES Evaluation Report for each type of steel decking used in the Work.

1.04 QUALITY ASSURANCE

- A. No insulation, roofing materials, or other permanent coverings shall be placed over the decking until the Engineer has inspected it for placement, welds, and accessories. Stored materials and debris shall be removed to facilitate the inspection. Welds found to be defective shall be replaced as a part of the Work.

1.05 MATERIAL STORAGE

- A. Decking stored at the Site before installation shall be stacked on the ground on platforms or pallets and be covered with tarpaulins or other weatherproof covering.

PART 2 -- PRODUCTS

2.01 STEEL DECK

- A. Unless indicated otherwise, steel deck shall be manufactured from steel conforming to ASTM A653 having a minimum yield strength of 50,000 psi.
- B. The steel deck structural properties shall be as indicated. The moment of inertia and section modulus of the steel deck unit shall be computed in accordance with the SDI specifications, and in accordance with AISI S100.
- C. Steel decking shall be galvanized and shall conform to ASTM A653 and to the applicable requirements of Section 05 50 00 – Metal Fabrications. Steel deck shall be free of oil, grease, and dirt before dipping.
- D. Steel deck shall be finished in accordance with Section 09 96 00 – High-Performance Coatings. Deck shall be free of oil, grease and dirt before coating application.
- E. The steel deck shall have sheet length that covers 3 or more spans.
- F. The steel deck sheets shall be formed at the longitudinal sides in such a manner that they will overlap and/or interlock. Where the end of sheets overlap, they shall be die-formed in such a manner that the sheet in the next row telescopes and snugly overlaps the sheet laid previously.
- G. Plates needed to connect decking to supports or to maintain deck continuity shall be 14-gauge galvanized sheet.

- H. Structural steel shapes, including angles and inserts, shall be in accordance with Section 05 50 00 – Metal Fabrications.

2.02 MANUFACTURERS

- A. The steel decking shall be manufactured by Verco Manufacturing Company, ASC Pacific Inc., Vulcraft Nucor Corporation Inc., or equal.

PART 3 -- EXECUTION

3.01 INSTALLATION REQUIREMENTS

- A. The Contractor shall inspect supporting members for correct layout and alignment, and shall not proceed with installation until defects are corrected and supporting members are completely installed and secured.
- B. Steel deck sheets and accessories shall be placed in accordance with the manufacturer's recommendations and the Shop Drawings. Roofs having a slope of 1/4-inch per foot or more shall be installed starting at the low side, to ensure that end laps are shingle fashion.
- C. Steel deck sheets shall be positioned on supporting steel framework and adjusted to final position with ends bearing a minimum of 2-inches on supporting members. Units shall be placed end to end, with ribs aligned over the entire length of the run before being permanently fastened.
- D. Special care shall be exercised not to damage or overload the deck during installation. The deck shall not be used for storage or as working platforms until permanently secured in position. Construction loads shall not exceed the deck carrying capacity, as recommended by the manufacturer.
- E. Openings in the deck shall be cut and fitted neatly and shall be reinforced with structural steel members to distribute the load.
- F. Where concrete fill is required, deck shall be installed with closure plates and other accessories as needed to prevent loss of water, cement, and fines during placing and consolidation of the concrete.
- G. Edges of any cut openings or any minor surface damage areas shall be repaired in accordance with applicable requirements of the Sections 09 96 00 – High-Performance Coatings and 05 50 00 – Metal Fabrications.
- H. After installation, surfaces shall be cleaned and left free of grime and dirt. The Contractor shall remove unused materials, tools, scaffolding, and debris from the premises and leave the area broom clean.

3.02 WELDING

- A. Care shall be exercised in the selection of electrodes and amperage to provide positive welds and to prevent high amperage blowholes. Welds shall be made from the top side of the deck immediately after alignment.

- B. The steel deck shall be welded to supporting members with 1/2-inch effective diameter puddle welds spaced at 12-inches on center at members parallel to the ribs and at every rib valley at members perpendicular to the ribs, unless otherwise indicated. Welding washers shall be used when welding steel deck of less than 0.028-inch thickness. Welding washers shall not be used when welding steel deck of 0.028-inches or greater.
- C. Side laps shall be welded with 1-1/2 inch long top seam welds, spaced at 12-inches on center unless indicated otherwise.
- D. Welds shall be free of sharp points or edges. Welds shall be cleaned immediately by chipping or wire brushing and shall be coated with a zinc dust type primer paint.
- E. Welding shall conform to the applicable requirements of AISI S100 and AWS D1.3. Welders shall be AWS certified.

END OF SECTION

SECTION 05 50 00 – METAL FABRICATIONS

PART 1 -- GENERAL

1.01 SUMMARY

- A. Provide miscellaneous metalwork and appurtenances, complete and in place, as indicated in accordance with the Contract Documents.

1.02 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

A. Referenced Specifications

01 33 00	Submittal Procedures
03 60 00	Grouting
04 05 19.16	Masonry Anchors
05 05 19	Post Installed Concrete Anchors
09 96 00	High-Performance Coatings

- B. References herein to "Building Code" shall mean the 2024 Ohio Building Code (OBC). The edition of the standards applicable to the Work shall be those editions referenced by the OBC. If the standard is not referenced by the OBC, nor an IBC-referenced standard listed below, the edition of the standard applicable to the Work shall be the edition in effect on the date of award of this contract.

Aluminum Association (AA)	
AA DAF-45	Designation System for Aluminum Finishes
American Institute of Steel Construction (AISC)	
AISC	Steel Construction Manual
AISC	Detailing for Steel Construction
American Iron and Steel Institute (AISI)	
AISI S100	North American Specification for the Design of Cold - Formed Steel Structural Members
AISI 1010	Carbon Steel
ASTM International (ASTM)	
ASTM A36	Standard Specification for Carbon Structural Steel
ASTM A53	Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
ASTM A123	Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
ASTM A153	Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware
ASTM A193	Standard Specification for Alloy-Steel and Stainless Steel Bolting for High Temperature or High Pressure Service and Other Special Purpose Applications
ASTM A194	Standard Specification for Carbon Steel, Alloy Steel, and Stainless Steel Nuts for Bolts for High Pressure or High Temperature Service

METAL FABRICATIONS

ASTM A307	Standard Specification for Carbon Steel Bolts, Studs, and Threaded Rod 60 000 PSI Tensile Strength
ASTM A500	Standard Specification for Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes
ASTM A513	Standard Specification for Electric-Resistance-Welded Carbon and Allow Steel Mechanical Tubing
ASTM A780	Standard Specification for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings
ASTM A992	Standard Specification for Structural Steel Shapes
ASTM A1011	Standard Specification for Steel, Sheet and Strip, Hot-Rolled, Carbon, Structural, High-Strength Low Alloy, High-Strength Low Alloy with Improved Formability, and Ultra-High Strength
ASTM A1085	Standard Specification for Cold-Formed Welded Carbon Steel Hollow Structural Sections (HSS)
ASTM F1554	Standard Specification for Anchor Bolts, Steel, 36, 55, and 105-ksi Yield Strength
ASTM F3125	Standard Specification for High Strength Structural Bolts, Steel and Alloy Steel, Heat Treated, 120 ksi and 150 ksi Minimum Tensile Strength
American Welding Society (AWS)	
AWS B1.5	Standard for the Qualification of Welding Inspectors
AWS D1.1	Structural Welding Code – Steel
AWS D1.2	Structural Welding Code - Aluminum
AWS D1.3	Structural Welding Code - Sheet Steel
AWS QC1	Qualification and Certification of Welding Inspectors
International Code Council (ICC)	
OBC	2024 Ohio Building Code
National Association of Architectural Metal Manufacturers (NAAMM)	
NAAMM MBG531	Metal Bar Grating Manual
NAAMM MBG532	Heavy Duty Metal Bar Grating Manual
United States Department of Labor - Occupational Safety and Health Administration (OSHA)	
OSHA 1910.23(d)	Fixed Ladders

1.03 CONTRACTOR SUBMITTALS

- A. Furnish submittals in accordance with the requirements of Section 01 33 00 – Submittal Procedures.
- B. Shop Drawings
 1. Shop Drawings shall conform to AISC Detailing for Steel Construction, and shall show all holes, material grades, and location of parts/pieces in the completed Work.

2. Shop Drawings shall include complete details of members and connections, anchor bolt layouts, schedules for fabrication procedures, and diagrams for the sequence of erection.

C. Grating

1. Submit layout drawings for grating, showing the direction of span, type and depth of grating, size and shape of grating panels, seat angle details, and details of grating hold down fasteners.
2. Submit load and deflection tables for each style and depth of grating used.

D. Anchor Submittals

1. For post installed anchors in concrete other than powder-driven pins or impact anchors, refer to Section 05 05 19 – Post Installed Concrete Anchors.
2. For post installed anchors in concrete masonry units other than powder-driven pins or impact anchors, refer to Section 04 05 19.16 – Masonry Anchors.
3. For cast-in-place anchors, powder-driven pins or impact anchors, complete structural calculations and anchorage details shall be prepared and submitted by the Contractor for all anchors and anchor groups that are shown but not completely detailed (type, size, location, spacing and embedment) on the Contract Documents. Calculations and anchorage details shall be signed and stamped by a Professional Engineer registered in the state in which the project is located.

1.04 QUALITY ASSURANCE

- A. Weld procedures and welder qualifications shall be available in the Contractor's field office for review.
- B. Welding Special Inspection shall be performed by the Owner in accordance with the enforceable Building Code.

PART 2 -- PRODUCTS

2.01 GENERAL REQUIREMENTS

A. Steel

Wide Flange Shapes	ASTM A992
Shapes, Plates, Bars	ASTM A36 unless indicated otherwise
Pipe, Pipe Columns, Bollards	ASTM A53, Type E or S, Grade B standard weight unless indicated otherwise
HSS	ASTM A500 Grade B or ASTM A1085

B. Corrosion Protection

1. Unless otherwise indicated, fabricated steel metalwork which will be used in a corrosive environment and/or will be submerged in water or wastewater shall be coated in accordance with the requirements of Section 09 96 00 – High-Performance Coatings and shall not be galvanized prior to coating.

METAL FABRICATIONS

2. Other miscellaneous steel metalwork shall be hot-dip galvanized after fabrication. Weight of galvanizing shall be G90 unless noted otherwise.

C. Stainless Steel

1. Unless otherwise indicated, stainless steel metalwork and bolts shall be fabricated from Type 316 stainless steel.

D. Aluminum

1. Unless otherwise indicated, aluminum metalwork shall be fabricated from Alloy 6061-T6.
2. Aluminum in contact with concrete, masonry, wood, porous materials, or dissimilar metals shall have contact surfaces coated in accordance with the requirements of Section 09 96 00 – High-Performance Coatings.

E. Cast Iron

1. Unless otherwise indicated, iron castings shall conform to the requirements of ASTM A48, Class 50B, or better.

2.02 METAL GRATING

A. General

1. Metal grating shall be of the indicated design, size, and type.
2. Grating shall be supported around an opening by support members.
3. Where grating is supported on concrete, provide embedded support angles, unless otherwise indicated. Support angles shall match the grating material and mitered and welded at their corners.
4. Banding
 - a. The grating shall be completely banded at edges and cutouts.
 - b. The banding material and cross-section thickness shall be equivalent to the bearing bars.
 - c. The banding shall be welded to each cut bearing bar.
5. The grating pieces shall be fastened to each support by positive means in 2 locations.
6. Where the grating depth is not indicated, provide grating within allowable stress levels and which shall not exceed a deflection of 1/4 inch or the span divided by 180, whichever is less.
7. Design Loading
 - a. For standard duty grating, unless otherwise indicated, the loading to be used for determining stresses and deflections shall be the uniform live load of the adjacent floor.

- b. For heavy duty grating, the loading to be used for determining stresses and deflections shall be a uniform live load of 300 psf or the live load limit of the adjacent floor, whichever governs.

8. Grating finish shall be serrated unless otherwise noted on the Contract Drawings.

B. Standard Duty Grating

1. Except where indicated otherwise, bar grating shall be fabricated entirely of:
 - a. aluminum
 - 1) Bearing and Banding Bars: Alloy 6061-T6
 - 2) Cross Bars: Alloy 6063-T5
2. No single piece of grating shall weigh more than 80 pounds, unless indicated otherwise.
3. Standard duty grating shall be composed of serrated bar grating.
4. Cross bars shall be welded or mechanically locked tightly into position such that there is no movement between the bearing and cross bars.

C. Heavy-Duty Grating

1. Heavy-duty grating shall be fabricated from welded steel, galvanized after fabrication.
2. Crossbars shall be welded in position.
3. Banding bars shall have a minimum thickness of 1/4".
4. Provide grating with checkerplate covered where indicated on the Contract Drawings.
5. Provide grating with integral hinged section where indicated on the Contract Drawings.

2.03 HATCHES - GENERAL

A. Configuration

1. Hatch opening sizes, number and swing direction of door leaves, and locations shall be as indicated.
2. Indicated sizes are for the clear opening.
3. Where the number of leaves is not indicated, openings larger than 42 inches in either direction shall be provided with double-leaf doors.
4. Unless indicated otherwise, hinges shall be located on the longer dimension side.
5. Unless indicated otherwise, ladder hatches shall be a minimum of 30 inches wide by 36 inches long, with the ladder centered on the shorter dimension and the door hinge opposite the ladder.

METAL FABRICATIONS

- B. Hatches shall be provided with an automatic hold-open arm with release handle.
- C. Hatches shall be designed for easy opening from both inside and outside.
- D. Hatches shall be provided with a recessed hasp for a padlock covered by a hinged lid that is flush with the surface.
- E. Safety Grates
 - 1. Unless indicated otherwise, hatch safety grates conforming to OSHA requirements shall be provided.
- F. Nets
 - 1. Unless indicated otherwise, hatch nets shall be provided on floor hatches.
 - 2. Hatch nets shall conform to OSHA requirements.
 - 3. Hatch nets shall be Hatch Net 121, as manufactured by Safe Approach, Inc, Auburn, ME, or equal.

2.04 ALUMINUM HATCHES

- A. Hatches shall be fabricated from aluminum 5086 H34, 6063-T5 or 6061-T6, unless otherwise indicated.
- B. Hatch hardware shall be fabricated from Type 316 stainless steel.
- C. Hatches shall be flush-type.
- D. The design live load shall be heavy duty traffic, unless indicated otherwise.
- E. Door leaves shall be fabricated from a minimum of 1/4-inch thick checkered-pattern plate.
- F. Channel frames shall be fabricated from a minimum 1/4-inch material with an anchor flange around the perimeter.
- G. Hatches shall be designed to be water-tight and shall be equipped with a joint gutter, a moat-type edge drain, and drain piping of the length and size necessary to remove the drain water from all dry spaces accessed by the hatch.
- H. A minimum 1-1/2 inch diameter drain connection shall be provided, located by the manufacturer.
- I. Hatches shall be provided with a recessed hasp for a padlock covered by a hinged lid that is flush with the surface.
- J. Hatches shall be EJ Co. Type CHS, Bilco Type J or JD, Babcock-Davis Type B-FGA, or equal.

2.05 LADDERS

- A. Materials

1. Ladders which may be partially or wholly submerged or which are located inside a hydraulic structure shall be fabricated entirely of Type 316 stainless steel, unless indicated otherwise.
2. Other ladders shall be fabricated from aluminum, unless noted otherwise.

B. Pop-Up Extension

1. Every ladder that does not extend above the access level shall be equipped with a pop-up ladder extension.
2. The pop-up ladder extension device shall be manufactured of the same material and finish as the ladder and shall be provided with a telescoping tubular section that locks automatically when fully extended.
3. Upward and downward movement shall be controlled by stainless steel spring balancing mechanisms.
4. The units shall be completely assembled with fasteners for securing to the ladder rungs in accordance with the manufacturer's instructions.

2.06 IRON CASTINGS

A. General

1. Iron castings shall be of uniform quality, free from blowholes, porosity, hard spots, shrinkage, distortion, or other defects.
2. The castings shall be smooth and well cleaned by shotblasting.
3. Covers and grates shall fit together evenly, such that the cover fits flush with the surrounding finished surface and such that the cover does not rock or rattle when a loading is applied.
4. Round covers and frames shall be provided with machined bearing surfaces.

B. Covers and grates with matching frames shall be designed to support the following loadings:

1. Where located within a structure, the design loading shall match that required for the adjacent floor area, or, if no floor loading is indicated, a minimum of 300 pounds per square foot.
2. Exterior covers and grates shall be designed for the maximum loading from the AASHTO HL-93 vehicle unless indicated otherwise.

2.07 MANHOLE RUNGS

A. Rungs shall meet ASTM C478 and the following requirements:

1. Rungs shall be spaced not less than 10 inches apart nor more than 14 inches apart, as measured between centerlines of the rungs.
2. Rungs shall be parallel, level, and uniformly spaced.

METAL FABRICATIONS

3. The rungs shall be shaped such that a person's foot cannot slide off the end of the rung.
 4. Rungs shall be surfaced to prevent injury from punctures or lacerations, and to prevent snagging of clothing.
 5. The minimum perpendicular clearance between rungs and any obstruction behind the ladder shall be 6 inches.
 6. The minimum width of rungs shall be 14 inches.
- B. Submit certified test results in accordance with ASTM C497, for the following loads:
1. The horizontal pull-out load shall be 400 pounds.
 2. The vertical load shall be 800 pounds.
- C. Material
1. Rungs shall be fabricated from co-polymer polypropylene that encapsulates a minimum 1/2-inch grade 60 steel reinforcing rod.
 2. The co-polymer polypropylene shall meet ASTM D4101, Type PP200B33430.

2.08 BOLTS AND ANCHORS

- A. Standard Service (Non-Corrosive Application)
1. Bolts, anchor rods, anchor bolts, washers, and nuts shall be fabricated from steel as indicated.
 2. Threads on galvanized bolts, rods and nuts shall be formed with suitable taps and dies such that they retain their normal clearance after hot-dip galvanizing.
 3. Except as otherwise indicated, steel for bolt material, anchor rods, anchor bolts, and cap screws shall be in accordance with the following requirements:
 - a. Structural Connections: ASTM A307, Grade A or B, hot-dip galvanized.
 - b. Headed Anchor Rods and Anchor Bolts: ASTM F1554, Grade 36, hot-dip or mechanically galvanized with Grade A matching nuts.
 - c. High-Strength Bolts, where indicated: ASTM F3125, Grade A325.
 - d. Pipe and Equipment Flange Bolts: ASTM A193, Grade B7.
- B. Corrosive Service
1. Bolts, anchor rods, anchor bolts, nuts, and washers in the locations listed below shall be fabricated from stainless steel as indicated.
 - a. buried locations
 - b. submerged locations
 - c. locations subject to seasonal or occasional flooding

METAL FABRICATIONS

- d. inside buried vaults, manholes, and structures that do not drain through a gravity sewer or to a sump with a pump
 - e. inside trenches, containment walls, and curbed areas
 - f. locations indicated or designated by the Engineer to be provided with stainless steel bolts
- C. Unless otherwise indicated, stainless steel bolts, nuts, anchor rods, and washers shall be fabricated from Type 316 stainless steel, Class 2, conforming to ASTM A193 for bolts and to ASTM A194 for nuts.
- D. Coating
 - 1. Threads on stainless steel bolts and rods shall be protected with an antiseize lubricant suitable for submerged stainless steel bolts, meeting government specification MIL-A-907E.
 - 2. Buried bolts in poorly drained soil shall be coated the same as the buried pipe.
 - 3. Antiseize lubricant shall be classified as acceptable for potable water use by the NSF.
 - 4. Antiseize lubricant shall be "PURE WHITE" by Anti-Seize Technology, Franklin Park, IL, 60131, AS-470 by Dixon Ticonderoga Company, Lakehurst, NJ, 08733, or equal.
- E. Bolt Requirements
 - 1. The bolt and nut material shall be free-cutting steel.
 - 2. The nuts shall be capable of developing the full strength of the bolts.
 - 3. Threads shall be Coarse Thread Series conforming to the requirements of the American Standard for Screw Threads.
 - 4. Bolts and cap screws shall have hexagon heads and nuts shall be Heavy Hexagon Series.
 - 5. Bolts and nuts shall be installed with washers fabricated from material matching the base material of bolts, except that hardened washers for high-strength bolts shall conform to the requirements of the AISC Specification.
 - 6. Lock washers fabricated from material matching the bolts shall be installed where indicated.
 - 7. The length of each bolt shall be such that the bolt extends at least 1/8 inch beyond the outside face of the nut before tightening, except for anchor bolts which shall be flush with the face of the nut before tightening.

2.09 POWDER-ACTUATED PINS

- A. Powder-actuated pins for installation in concrete or steel shall be fabricated from heat-treated steel alloy.

- B. If the pins are not inherently sufficiently corrosion-resistant for the conditions to which they will be exposed, they shall be protected in an acceptable manner.
- C. Pins shall have capped or threaded heads capable of transmitting the loads the shanks are required to support.
- D. Pins that are connected to steel shall be provided with longitudinal serrations around the circumference of the shank.

2.10 IMPACT ANCHOR

- A. Impact anchors shall be an expansion-type anchor in which a nail-type pin is driven to produce the expansive force.
- B. The pin shall be provided with a zinc sleeve with a mushroom-style head and stainless steel nail pin.
- C. Anchors shall be Zinc Nailon Anchors, manufactured by Simpson Strong-Tie, Inc., Metal Hit Anchors, manufactured by Hilti, Inc., Rawl Zamac Nailin, manufactured by the Rawlplug Company, or equal.

PART 3 -- EXECUTION

3.01 FABRICATION AND INSTALLATION REQUIREMENTS

- A. Fabrication and Erection: Except as otherwise indicated, the fabrication and erection of structural steel shall conform to the requirements of the American Institute of Steel Construction "Manual of Steel Construction."
- B. Powder-Actuated Pins
 - 1. Powder-actuated pins shall be installed by a craftsperson certified by the manufacturer as being qualified to install the manufacturer's pins.
 - 2. Pins shall be driven in one initial movement by an instantaneous force that has been carefully selected to attain the required penetration.
 - 3. Driven pins shall conform to the following requirements where "D" is equal to the pin shank diameter:

Material Penetrated by Pin	Material Minimum Thickness	Pin Shank Penetration in Supporting Material	Minimum Space From Pin's CL to Edge of Penetrated Material	Minimum Pin Spacing
Concrete	16D	6D minimum	14D	20D
Steel	1/4-inch	Steel thickness	4D	7D

3.02 WELDING

- A. Method
 - 1. Welding shall be performed by the metal-arc method or gas-shielded arc method as described in the American Welding Society "Welding Handbook" as supplemented by other pertinent standards of the AWS.

2. The qualification of the welders shall be in accordance with the AWS Standards.

B. Quality

1. In assembly and during welding, the component parts shall be adequately clamped, supported, and restrained in order to minimize distortion and for control of dimensions.
2. Weld reinforcement shall be as indicated by the AWS Code.
3. Upon completion of welding, remove weld splatter, flux, slag, and burrs left by attachments.
4. Welds shall be repaired in order to produce a workmanlike appearance, with uniform weld contours and dimensions.
5. Sharp corners of material that is to be painted or coated shall be ground to a minimum of 1/32 inch on the flat.

3.03 GALVANIZING

- A. Structural steel plates shapes, bars, and fabricated assemblies required to be galvanized shall, after the steel has been thoroughly cleaned of rust and scale, be galvanized in accordance with the requirements of ASTM A123.
- B. Any galvanized part that becomes warped during the galvanizing operation shall be straightened.
- C. Bolts, anchor rods, anchor bolts, nuts, and similar threaded fasteners, after being properly cleaned, shall be galvanized in accordance with the requirements of ASTM A153.
- D. Field Repairs
 1. Galvanizing shall be repaired in accordance with ASTM A780.
 2. Surface preparation shall consist of removing oil, grease, soil, and soluble material by cleaning with water and detergent (SSPC SP1) followed by brush-off blast cleaning (SSPC SP7) over an area extending at least 4 inches into the undamaged area.
 3. The coating shall be applied to at least 3 mils dry film thickness, and shall be Zinc-Clad XI by Sherwin-Williams, Galvax by Alvin Products, Galvite by ZRC Worldwide, or equal.

END OF SECTION

SECTION 07 11 00 – DAMPPROOFING

PART 1 -- GENERAL

1.01 SUMMARY

A. Section Includes:

1. Dampproofing

1.02 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

- A. Where reference is made to any of the below, the revision in effect at the time of bid opening shall apply.

B. Reference Specifications

01 33 00	Submittal Procedures
04 21 13	Brick Masonry
07 21 13	Board Insulation

C. Reference Standards

American Society for Testing and Materials (ASTM)	
ASTM D 1187	Asphalt-Base Emulsions for Use as Protective Coatings for Metal
ASTM D 1227	Emulsified Asphalt Used as a Protective Coating for Roofing

1.03 SUBMITTALS

- A. The Contractor shall furnish submittals in accordance with Section 01 33 00 – Submittal Procedures.

1.04 ACTION SUBMITTALS

A. Product Data

1. Manufacturer's specifications, technical data, installation methods, and maintenance instructions.

B. Certificates

1. Certification by the dampproofing Manufacturer that the dampproofing provided is suitable for, and compatible with, the required installation.
2. Certification by the dampproofing Manufacturer that the products supplied comply with local regulations controlling the use of volatile organic compounds (VOCs).
3. Certification of Manufacturer qualifications demonstrating compliance with the qualifications requirements indicated. Include a list of 5 similar completed projects with addresses of the project location, date of project completion, Manufacturer's products, and contact information of the consultant firm of record, general contractor and Owner.

4. Certification of installer qualifications demonstrating compliance with the qualifications requirements indicated. Include a list of 5 similar completed projects with addresses of the project location, date of project completion, and contact information of the consultant firm of record, general contractor and Owner.

C. Application Schedule

1. Furnish a detailed and complete application schedule indicating location and detail of installation.

D. Samples

1. When requested by Engineer, submit samples of the materials proposed. Samples shall be clearly marked to show the Manufacturer's name, product identification, finish and color. New samples shall be resubmitted of each, as required, until approved by Engineer. Upon approval, the samples shall become the standard for acceptance for the project with regard to color, finish, and quality of each item. Approval of samples shall not relieve Contractor from compliance with the Contract Documents.

1.05 QUALITY ASSURANCE

A. Qualifications

1. Manufacturers

- a. Minimum of 10 years of dampproofing manufacturing experience.
- b. Minimum of 5 similar successful projects over the most recent 10 years, employing similar products, materials, applications, and performance requirements.

2. Installers

- a. Minimum of 5 years' experience in the successful completion of at least 5 projects of similar size and scope, employing similar products, materials, applications, and performance requirements.

B. Manufacturer's Technical Field Representative

1. The Contractor shall arrange for a Manufacturer's technical field representative to be on Site for at least 3 days, beginning at the start of surface preparation and continuing through application, to train the installers and to supervise the Work. The Manufacturer's technical field representative shall observe as necessary to certify in writing that the completed Work has been performed according to the Manufacturer's instructions.

1.06 WARRANTY

A. Manufacturer Warranty

1. Furnish Manufacturer's 5-year written warranty to cover defects in materials, products, and manufacturing workmanship.

B. Special Warranty

1. The Contractor shall furnish separate, but concurrently running, 5-year written warranty to cover labor.

C. Warranty Provisions

1. Warranties shall be non-prorated for the entire warranty period.
2. The term of the warranties shall begin on the date of Substantial Completion.

PART 2 -- PRODUCTS

2.01 DAMPROOFING

- A. Dampproofing shall be suitable for, and compatible with, the insulation provided under Section 07 21 13 – Board Insulation.

B. Manufacturer and Product, or Equal:

1. MasterSeal 615 by Sika, including primer as recommended by Manufacturer.

C. Performance Requirements

1. Cold-applied water-based emulsified-asphalt dampproofing and vapor-retarding coating for concrete and concrete block foundation and cavity wall applications, suitable for installation on “green” or slightly damp surfaces.
2. Shall be reinforced with short fibers for application by brush or spray.
3. Dampproofing shall comply with ASTM D 1227, Type 2, Class I, and ASTM D 1187, Type 1.

2.02 PROTECTION BOARD

- A. Provide dampproofing manufacturer’s recommended protection board, which shall be compatible with dampproofing.

- B. Description: Protection board shall be suitable for the protection of dampproofing from damage during backfill operations, as recommended in writing by the dampproofing manufacturer.

PART 3 -- EXECUTION

3.01 DELIVERY, STORAGE, AND HANDLING

- A. Deliver materials to Site in Manufacturer’s original, unopened packages, containers, or bundles with labels intact, which clearly identify contents.

- B. Store materials carefully in accordance with the Manufacturer’s written instructions, in an area that is protected from deleterious elements, and in a manner that will prevent damage to the products.

- C. Handle materials in strict accordance with Manufacturer’s written instructions.

3.02 APPLICATION SCHEDULE

- A. Dampproofing shall be installed on exterior face of foundation walls from top of footing, up to 2-in below finish grade line, to continuously dampproof below grade rooms or other internal spaces.
- B. Dampproofing shall also be installed elsewhere, where noted on the Contract Drawings.
- C. Protection board shall be applied at locations where foundation insulation is not otherwise provided in order to protect the dampproofing during backfill operations.

3.03 PROJECT CONDITIONS

- A. Comply with Manufacturer's written instructions for environmental conditions before, during, and after installation.
- B. Protect surrounding Work from damage that may result from operations under this Section.

3.04 INSPECTION

- A. The Contractor shall be totally responsible for the proper performance and completion of the Work under this Section.
- B. Systems and components shall be inspected before installation.
 - 1. Damaged or defective items shall be rejected and marked as such and shall be removed from the Site.
- C. The Contractor shall verify dimensions, tolerances, and method of attachment with adjacent Work.
 - 1. Examine substrates, areas, and conditions where dampproofing will be installed for compliance with the requirements for installation, taking into account tolerances, and other conditions affecting performance of installed dampproofing.
 - a. Surfaces to receive dampproofing shall be dry, free of oil, dirt, dust and other contaminants and loose materials, and shall be in the proper condition as indicated by the Manufacturer prior to the application of the dampproofing materials.
 - b. Masonry, concrete, and cementitious products shall have been completely cured and the surface shall be dry and free from frost at the time of application.
 - 2. Notify Engineer in writing of conditions detrimental to the proper and timely completion of the Work. Do not proceed with the Work until unsatisfactory conditions have been corrected in an acceptable manner.
 - 3. Commencement of the installation by Contractor shall indicate Contractor's acceptance of the substrate, areas, and conditions.

3.05 SURFACE PREPARATION

- A. Surface preparation shall be in compliance with the applicable references and with the Manufacturer's written instructions.
- B. Coatings, including curing compounds, form release agents, and other substances shall be removed as recommended by the dampproofing Manufacturer.
- C. Protrusions, bumps, ridges, and loose substrate surface materials shall be removed by sanding or grinding.
- D. Trowelable leveling and patching compounds shall be used per dampproofing Manufacturer's written instructions to fill cracks, holes, and depressions.
- E. Immediately before application of dampproofing materials, scrape surfaces to be covered free from foreign materials and brush clean.
- F. Substrate shall be swept to remove all loose materials prior to beginning dampproofing installation.

3.06 PREPARATION

- A. Sequence installation properly with the installation and protection of other Work, so that neither will be damaged by the installation of the other.
 - 1. Do not begin dampproofing until penetrations have been installed so that dampproofing will not be penetrated or damaged by subsequent Work.
 - 2. Do not begin dampproofing before plumbing, electrical, mechanical, and structural items under or passing through dampproofing have been secured in proper positions and appropriately sealed and protected.

3.07 INSTALLATION

- A. Installation shall comply with the requirements of the Contract Documents, with applicable references, and with Manufacturer's written instructions. Where a conflict occurs among these requirements, the more stringent shall apply, as directed by the Engineer.
- B. Particular care shall be given to the application of dampproofing at construction joints.
- C. Primer, if recommended by the Manufacturer for the application, shall be applied per the Manufacturer's recommended procedures.
- D. Surfaces to be dampproofed shall receive 2 heavy coats, the first coat being carefully applied so that "holidays" or untreated air-bubble depressions in the surface shall be completely filled and the second coat shall provide a 100 percent coating of the surface.
- E. Install foundation insulation in Section 07 21 13 – Board Insulation, against dampproofing.
- F. Dampproofing shall be cured prior to backfilling.

- G. Install protection board against dampproofing as recommended in writing by the dampproofing manufacturer.

3.08 CLEANING, FINISHING, AND PROTECTION

- A. Dampproofing shall be protected from damage from subsequent construction operations.
- B. The Contractor shall make adjustments required until accepted.
- C. Damaged or defective items shall be removed and replaced as determined by the Engineer.
- D. When dampproofing Work is completed, remove unused materials, containers, and equipment, and clean the Site of dampproofing debris.

END OF SECTION

SECTION 07 21 13 – BOARD INSULATION

PART 1 -- GENERAL

1.01 SUMMARY

A. Section Includes

1. Foundation insulation

1.02 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

- A. Where reference is made to any of the below, the revision in effect at the time of bid opening shall apply.

B. Reference Specifications

01 33 00	Submittal Procedures
07 11 00	Dampproofing

C. Reference Standards

American Society for Testing and Materials (ASTM)3zx	
ASTM C 272	Standard Test Method for Water Absorption of Core Materials for Structural Sandwich Constructions
ASTM C 518	Standard Test Method for Steady-State Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus
ASTM C 578	Rigid, Cellular Polystyrene Thermal Insulation
ASTM D 1621	Standard Test Methods for Compressive Properties of Rigid Cellular Plastics
ASTM D 4716	Test Method for Determining the (In-Plane) Flow Rate per Unit Width and Hydraulic Transmissivity of a Geosynthetic Using a Constant Head

1.03 SUBMITTALS

- A. Furnish submittals in accordance with Section 01 33 00 – Submittal Procedures.

1.04 ACTION SUBMITTALS

A. Product Data

1. Manufacturer's specifications, technical data, installation methods, and maintenance instructions.

B. Certifications:

1. Certification by the Manufacturer that the foundation insulation is suitable for, and compatible with, the dampproofing provided under Section 07 11 00 – Dampproofing.

C. Application Schedule

BOARD INSULATION

1. Furnish a detailed and complete application schedule indicating location and detail of installation.

D. Samples

1. When requested by the Engineer, submit samples of the materials proposed. Samples shall be clearly marked to show the Manufacturer's name, product identification, finish, and color. New samples shall be resubmitted of each, as required, until approved by the Engineer. Upon approval, the samples shall become the standard for acceptance for the project with regard to color, finish, and quality of each item. Approval of samples shall not relieve the Contractor from compliance with the Contract Documents.

1.05 QUALITY ASSURANCE

A. Single Source Responsibility

1. Foundation insulation shall be provided by a single Manufacturer.

B. Qualifications

1. Manufacturer

- a. Minimum of 10 years of foundation insulation manufacturing experience.
- b. Minimum of 5 similar successful projects over the most recent 10 years, employing similar products, materials, applications, and performance requirements.

1.06 WARRANTY

A. Manufacturer Warranty

1. Furnish the Manufacturer's 15-year written thermal warranty.
2. Warranties shall be non-prorated for the entire warranty period.

PART 2 -- PRODUCTS

2.01 FOUNDATION INSULATION

- A. Foundation insulation shall be suitable for, and compatible with, the dampproofing provided under 07 11 00 – Dampproofing.

2.02 MANUFACTURER

A. Manufacturer and Product, or Equal

1. Subject to the requirements indicated, provide Manufacturer and product listed below, or equal:
 - a. DuPont Styrofoam Perimate XPS Foam Insulation.

B. Description

BOARD INSULATION

1. Foundation insulation shall be a 2 1/8-in extruded closed cell polystyrene foam board with drainage grooves and with integral high-density skins of same material.
2. Foundation insulation shall comply with ASTM C 578 Type IV, and shall have a minimum R-value of 10.0 (5 per inch) at 75 deg F (23.9 deg C), sq ft × h × degrees F/Btu, in accordance with ASTM C 518. Foundation insulation shall have a minimum compressive strength of 30 psi in accordance with ASTM D 1621, maximum water absorption of 0.1 percent by volume, in accordance with ASTM C 272, and drainage capacity at 1200 psf, gradient 0.19 of 3 gal/min/ft in accordance with ASTM D 4716.

PART 3 -- EXECUTION

3.01 DELIVERY, STORAGE, AND HANDLING

- A. Deliver materials to Site in Manufacturer's original, unopened packages, containers, or bundles with labels intact, which clearly identify contents.
- B. Store materials carefully in accordance with the Manufacturer's written instructions, in an area that is protected from deleterious elements, and in a manner that will prevent damage to the products.
- C. Handle materials in strict accordance with Manufacturer's written instructions.

3.02 APPLICATION SCHEDULE

- A. Install foundation insulation vertically to reach a depth of 3 ft 0-in below grade, or to depth shown on the Drawings (whichever is greater) to continuously insulate the exterior face of exterior foundation walls, and other surfaces and substrates where indicated, in strict accordance with Manufacturer's written instructions.
- B. Foundation insulation shall also be installed elsewhere, where noted on the Drawings.

3.03 PROJECT CONDITIONS

- A. Comply with Manufacturer's written instructions for environmental conditions before, during, and after installation.
- B. Protect surrounding Work from damage that may result from operations under this Section.

3.04 INSPECTION

- A. The Contractor shall be totally responsible for the proper performance and completion of the Work under this Section.
- B. Systems and components shall be inspected before installation.
 1. Damaged or defective items shall be rejected and marked as such and shall be removed from the Site.
- C. The Contractor shall verify dimensions, tolerances, and method of attachment with adjacent Work.

1. Examine substrates, areas, and conditions where foundation insulation will be installed for compliance with the requirements for installation, taking into account tolerances, and other conditions affecting performance of installed foundation insulation.
 - a. Surfaces to receive foundation insulation shall be dry, free of oil, dirt, dust and other contaminants and loose materials, and shall be in the proper condition as indicated by the Manufacturer prior to the application of the foundation insulation materials.
 - b. Masonry, concrete, and cementitious products shall have been completely cured and the surface shall be dry and free from frost at the time of application.
2. Notify the Engineer in writing of conditions detrimental to the proper and timely completion of the Work. Do not proceed with the Work until unsatisfactory conditions have been corrected in an acceptable manner.
3. Commencement of the installation by the Contractor shall indicate Contractor's acceptance of the substrate, areas, and conditions.

3.05 PREPARATION

- A. Sequence installation properly with the installation and protection of other Work, so that neither will be damaged by the installation of the other.

3.06 INSTALLATION

- A. Installation shall comply with the requirements of the Contract Documents, with applicable references, and with Manufacturer's written instructions. Where a conflict occurs among these requirements, the more stringent shall apply, as directed by the Engineer.
- B. Foundation insulation shall be set with top 2-in below finish grade and held firmly in place in the freshly dampproofed concrete with additional daubs of dampproofing mastic in strict accordance with the Manufacturer's instructions. Refer to Section 07 11 00 – Dampproofing.

3.07 CLEANING, FINISHING, AND PROTECTION

- A. Foundation insulation shall be protected from damage from subsequent construction operations.
- B. The Contractor shall make adjustments required until accepted.
- C. Damaged or defective items shall be removed and replaced at the direction of the Engineer.
- D. When foundation insulation Work is completed, remove unused materials, containers, and equipment, and clean the Site of foundation insulation debris.

END OF SECTION

SECTION 07 92 13 – ELASTOMERIC JOINT SEALANTS

PART 1 -- GENERAL

1.01 SUMMARY

A. Section Includes:

1. Sealants and caulking.

1.02 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

- A. Where reference is made to any of the below, the revision in effect at the time of bid opening shall apply.

B. Reference Codes

01 33 00	Submittal Procedures
03 15 00	Concrete Accessories

C. Reference Standards

American Society for Testing and Materials (ASTM)	
ASTM C 920	Elastomeric Joint Sealants
ASTM D 1752	Preformed Sponge Rubber and Cork Expansion Joint Fillers for Concrete Paving and Structural Construction
Sealant, Waterproofing, and Restoration Institute (SWRI)	

1.03 SUBMITTALS

- A. Furnish submittals in accordance with Section 01 33 00 – Submittal Procedures.
- B. The Contractor shall coordinate color samples with other Sections through the submittal process, as required by the Engineer.

1.04 ACTION SUBMITTALS

A. Product Data

1. Manufacturer's specifications, technical data, installation methods, and maintenance instructions, and the following:
2. Joint width and depth tables.
3. Manufacturer's full range color charts, indicating custom color availability, for color selection by Owner.

B. Certifications:

1. Certification of installer qualifications demonstrating compliance with the qualifications requirements indicated. Include a list of 5 similar completed projects with addresses of the project location, date of project completion, and contact information of the consultant firm of record, general contractor and owner.

ELASTOMERIC JOINT SEALANTS

2. Certification by the Manufacturer's technical field representative that surfaces have been prepared and the products have been applied in accordance with the Manufacturer's recommendations.
3. Certification from an independent testing laboratory that the submitted materials meet the requirements of the references indicated.

C. Application Schedule

1. Furnish a detailed and complete application schedule indicating location and detail of installation.

D. Samples

1. When requested by the Engineer, submit samples of the materials proposed. Samples shall be clearly marked to show the Manufacturer's name, product identification, finish and color. New samples shall be resubmitted of each, as required, until approved by the Engineer. Upon approval, the samples shall become the standard for acceptance for the project with regard to color, finish, and quality of each item. Approval of samples shall not relieve the Contractor from compliance with the Contract Documents.

1.05 QUALITY ASSURANCE

A. Single Source Responsibility

1. Sealants and Caulking shall be provided by a single Manufacturer, each.

B. Qualifications

1. Manufacturer

- a. Sealants and caulking Manufacturer shall have a minimum of 20 years of sealants and caulking manufacturing experience.

2. Installer

- a. Installer shall have a minimum of 5 years' experience in the successful completion of at least 5 projects of similar size and scope, employing similar products, materials, applications, and performance requirements.

C. Manufacturer's Technical Field Representative

1. The Contractor shall arrange for a Manufacturer's technical field representative to be on Site for at least 1 day, beginning at the start of surface preparation and continuing through application, to train the installers and to supervise the Work. The Manufacturer's technical field representative shall observe as necessary to certify in writing that the completed Work has been performed according to the Manufacturer's instructions.

D. Sealant and caulking Work shall comply with the following references:

1. SWRI.
2. ASTM C 920.

1.06 WARRANTY

A. Manufacturer

1. Furnish Manufacturer's 5-year written warranty to cover defects in materials, products, and manufacturing workmanship.

B. Special Warranty

1. The Contractor shall furnish separate, but concurrently running, 5-year written warranty to cover labor.

C. Warranties shall be non-prorated for the entire warranty period.

D. The term of the warranties shall begin on the date of Substantial Completion.

PART 2 -- PRODUCTS

2.01 GENERAL

- A. Sealant and caulking, including compressible filler and joint backing, shall be recommended by the Manufacturer for the installation indicated.
- B. Sealant and caulking, including compressible filler and joint backing, shall be suitable for, and compatible with, the required installation.
- C. Sealant and caulking, including compressible filler and joint backing, shall be suitable for, and compatible with, the substrates and surfaces indicated.
- D. Refer to Section 03 15 00 – Concrete Accessories for joint treatment in concrete hydraulic structures.
- E. Colors for sealants and caulking above grade and exposed to view shall be selected by the Owner from Manufacturer's full color range, including custom colors.

2.02 INTERIOR AND EXTERIOR SEALANTS (HORIZONTAL OR SLOPED PLANES)

A. Manufacturer and Product, or Equal:

1. Subject to the requirements indicated, provide Manufacturer and product listed below, or equal:
 - a. MasterSeal SL2 by Sika, including primer as recommended by Manufacturer.

B. Description: Two part, pour grade polyurethane base, ASTM C 920, Type M, Grade P, Class 25, Use T, NT, M, A, and I.

2.03 INTERIOR AND EXTERIOR SEALANTS (VERTICAL PLANE)

A. Manufacturer and Product, or Equal:

1. Subject to the requirements indicated, provide Manufacturer and product listed below, or equal:
 - a. MasterSeal NP2 by Sika, including primer as recommended by Manufacturer.

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- B. Description: Multi-component, gun grade, polyurethane ASTM C 920, Type M, Grade NS Class 25, Use NT, T, M, A, G, and O.

2.04 COMPRESSIBLE FILLER

A. Manufacturer and Product, or Equal:

1. Subject to the requirements indicated, provide Manufacturer listed below, or equal:
 - a. Hohmann & Barnard.

B. Description:

1. Compressible filler shall be an impregnated preformed compressible sealant, produced by combining permanently elastic, high density open cell, polyurethane foam with stabilizing acrylics. Compressible filler shall be supplied pre-compressed in a tape form with a PSA on one side.
2. Compressible filler shall be compatible with sealant Manufacturer's product and shall not stain the sealant nor the materials to which applied.

2.05 JOINT BACKING (BACKER ROD)

A. Description:

1. Joint backing for joints in superstructure shall be approved, resilient, closed cell polyethylene rods of diameters to suit joint conditions. Joint backing shall comply with ASTM D 1752, Type II or III.
2. Where joint depth will not allow for a rod and still provide 3/8-in minimum depth of sealant, provide approved bond breaker tape at the bottom of the joint.
3. Joint backing shall be compatible with sealant Manufacturer's product and shall not stain the sealant nor the materials to which applied.

PART 3 -- EXECUTION

3.01 DELIVERY, STORAGE, AND HANDLING

- A. Deliver materials to Site in Manufacturer's original, unopened packages, containers, or bundles with labels intact, which clearly identify contents.
- B. Store materials carefully in accordance with the Manufacturer's written instructions, in an area that is protected from deleterious elements, and in a manner that will prevent damage to the products.
- C. Handle materials in strict accordance with Manufacturer's written instructions.

3.02 APPLICATION SCHEDULE

- A. Joints noted as "caulk," "caulking," or "sealant" shall be caulked as specified herein.

- B. Joints to be caulked or sealed include through-bolt holes, door frames, louver and ventilator frames, joints between openings where items pass through exterior walls, concrete masonry, or combination of these surfaces, and as otherwise indicated or required for watertightness, weatherproofing, or airtightness.
 - 1. Sealants and caulking shall be provided at both exterior and interior surfaces of exterior wall penetrations.
- C. Sealants and caulking shall be provided at exterior wall joints, between adjacent materials, joints between frames or louvers and adjacent materials, copings, caps, sills, masonry control joints, and other joints and penetrations indicated or required for the completion of the Work.
- D. Sealants and caulking shall be provided at interior joints between frames and masonry, at tops of masonry walls, between masonry and structural concrete, floor joints in tile, joints in rooms to be airtight, and other joints and penetrations on the Contract Drawings or as required for the completion of the Work.
- E. Sealants and caulking shall also be installed elsewhere, where indicated on the Contract Drawings.

3.03 PROJECT CONDITIONS

- A. Comply with Manufacturer's written instructions, and referenced standards, for environmental conditions before, during, and after installation.
- B. Protect surrounding Work from damage that may result from operations under this Section.

3.04 INSPECTION

- A. The Contractor shall be totally responsible for the proper performance and completion of the Work under this Section.
- B. Systems and components shall be inspected before installation.
 - 1. Damaged or defective items shall be rejected and marked as such and shall be removed from the Site.
- C. The Contractor shall verify dimensions, tolerances, and method of attachment with adjacent Work.
 - 1. Examine substrates, areas, and conditions where sealants and caulking will be installed for compliance with the requirements for installation, taking into account tolerances, and other conditions affecting performance of installed sealants and caulking.
 - a. Surfaces to receive sealants and caulking, including compressible filler and joint backing, shall be dry, free of oil, dirt, dust and other contaminants and loose materials, and shall be in the proper condition as indicated by the Manufacturer prior to the application of the sealant and caulking materials.
 - b. Masonry, concrete, and cementitious products shall have been completely cured and the surface shall be dry and free from frost at the time of application.

- c. Joint shapes and sizes shall be as indicated. Where not indicated, joint shapes and sizes shall be as necessary for job conditions, as directed by the Engineer.
2. Notify the Engineer in writing of conditions detrimental to the proper and timely completion of the Work. Do not proceed with the Work until unsatisfactory conditions have been corrected in an acceptable manner.
3. Commencement of the installation by the Contractor shall indicate Contractor's acceptance of the substrate, areas, and conditions.

3.05 SURFACE PREPARATION

- A. Surface preparation shall be in compliance with the applicable references and with the Manufacturer's written instructions.
- B. Coatings, including curing compounds, form release agents, and other substances shall be removed as recommended by the sealant and caulking Manufacturer.
- C. Protrusions, bumps, ridges, and loose substrate surface materials shall be removed by sanding or grinding.
- D. Laitance, efflorescence, and loose mortar shall be removed from the joint cavity.
- E. Ferrous metal surfaces shall be cleaned of rust, mill scale, and other coatings by wire brush, grinding, or sandblasting.
- F. Protective coatings shall be removed from surfaces to receive sealants and caulking.
 1. Solvents used to remove protective coating shall be as recommended by the sealant and caulking Manufacturer, shall be compatible with the adjacent materials and surfaces, shall not damage adjacent finishes, and shall be non-staining.
- G. Bituminous or resinous materials shall be removed from surfaces to receive sealants and caulking.
- H. Immediately before application of sealant and caulking materials, scrape surfaces to be covered free from foreign materials and brush clean.
- I. Substrate shall be swept to remove all loose materials prior to beginning sealant and caulking installation.

3.06 PREPARATION

- A. Sequence installation properly with the installation and protection of other WORK, so that neither will be damaged by the installation of the other.

3.07 INSTALLATION

- A. Installation shall comply with the requirements of the Contract Documents, with applicable references, and with Manufacturer's written instructions. Where a conflict occurs among these requirements, the more stringent shall apply, as directed by the Engineer.
- B. Primer, if recommended by the Manufacturer for the application, shall be applied per the Manufacturer's recommended procedures.

1. Primer shall be used on concrete masonry units, wood, or other porous surfaces in accordance with instructions furnished with the sealant. Primer shall be applied to the joint surfaces to be sealed. Surfaces adjacent to joints shall not be primed.
- C. Multi-component sealants shall be mixed according to Manufacturer's printed instructions. Sealant in guns shall be applied with a nozzle of proper size to fit the width of joint. Sealant shall be installed to the required depth without displacing the backing. Unless otherwise indicated or recommended by the Manufacturer, the installed sealant shall be tooled so that the surface is uniformly smooth and free of wrinkles and to assure full adhesion to the sides of the joint. Sealants shall be installed free of air pockets, foreign embedded matter, ridges, and sags. Sealer shall be applied over the sealant if recommended by the sealant Manufacturer.
- D. Sealant depth in joints shall be half of the width of joint, but not less than 1/8-in deep and 1/4-in wide nor more than 1/2-in deep and 1-in. For joints greater than 1-in wide, provide sealant in a 2 to 1 width-to-depth ratio.
- E. Joints shall have a rigid filler material installed to proper depth prior to application of sealant.
- F. Masking film shall be placed on the finish surface on one or both sides of a joint cavity to protect adjacent finish surfaces from primer or sealant smears. Masking shall be removed as soon as possible after joint has been filled and tooled.
- G. Backing shall be installed to provide the indicated sealant depth. The installation tool shall be shaped to avoid puncturing the backing.
- H. Bond-breaker shall be applied to fully cover the bottom of the joint without contaminating the sides where sealant adhesion is required.
- I. A full bead of sealant shall be applied into the joint under sufficient pressure, with the nozzle drawn across sealant, to completely fill the void space and to ensure complete wetting of contact area to obtain uniform adhesion. During application, the tip of the nozzle shall be kept at the bottom of the joint thereby forcing the sealant to fill from the bottom to the top. Sealants shall be tooled immediately after exposure with a caulking tool or soft bristled brush moistened with solvent. The finished sealant-filled joint shall be slightly concave unless otherwise indicated.

3.08 CLEANING, FINISHING, AND PROTECTION

- A. Adhesive papers used for masking which become firmly bonded when exposed to heat and/or light shall not be used.
 1. Remove masking film and temporary labels as soon as possible after installation. Films and labels left in place after installation shall be the responsibility of the Contractor.
 2. Residue shall not be left on any surfaces.
 3. The surfaces of materials adjoining caulked joints shall be cleaned free of smears of sealant or other soiling due to caulking operations.
- B. Sealants and caulking shall be protected from damage from subsequent construction operations.

- C. The Contractors shall make adjustments required until accepted.
- D. Damaged or defective items shall be removed and replaced at the direction of the Engineer.
- E. When sealant and caulking Work is completed, remove unused materials, containers, and equipment, and clean the Site of sealant and caulking debris.

END OF SECTION

SECTION 08 11 13 – HOLLOW METAL DOORS AND FRAMES

PART 1 -- GENERAL

1.01 SUMMARY

A. Section Includes:

1. Steel doors and frames.

1.02 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

A. Reference Specifications

01 33 00	Submittal Procedures
01 33 17	Structural Design, Support and Anchorage
08 71 00	Door Hardware
08 81 00	Glass Glazing
09 96 00	High Performance Coatings

- B. Where reference is made to any of the below, the revision in effect at the time of bid opening shall apply.

C. Reference Standards

American National Standards Institute (ANSI) / Steel Door Institute (SDI)	
ANSI A 115 -	Specification for Preparation of Steel Doors and Frames for Hardware
ANSI/SDI A 250.6 -	Recommended Practice for Hardware Reinforcing on Standard Steel Doors and Frames
ANSI A 250.8/SDI 100-	Recommended Specifications for Standard Steel Doors and Frames
ASTM International (ASTM)	
ASTM A 153	Zinc Coating (Hot Dip) on Iron and Steel Hardware
ASTM A 653	Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process
Building Code	
Refer to the Drawings to determine which Building Code applies. The applicable Building Code, defined by the Drawings, is referenced herein as "the Code"	
National Fire Protection Association (NFPA)	
NFPA 80	Fire Doors and Windows
NFPA 252	Standard Methods of Fire Tests of Door Assemblies
Steel Door Institute (SDI)	
Recommended Locations for Builders' Hardware for Standards Steel Doors and Frames	
Underwriters' Laboratories (UL)	
UL 10	Standard for Fire Test Door and Assemblies

UL 10C	Positive Pressure Fire Tests of Door Assemblies
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1.03 SUBMITTALS

- A. Product Furnish submittals in accordance with Section 01 33 00 –Submittal Procedures.

1.04 ACTION SUBMITTALS

A. Product Data:

1. Manufacturer's specifications, technical data, installation methods, and maintenance instructions.

B. Certifications:

1. Certification of compliance with the requirements of paragraph 2.1.A.
2. Certification of Manufacturer qualifications demonstrating compliance with the qualifications requirements indicated. Include a list of 5 similar completed projects with addresses of the project location, date of project completion, Manufacturer's products, and contact information of the consultant firm of record, general contractor and owner.
3. Certification of installer qualifications demonstrating compliance with the qualifications requirements indicated. Include a list of 5 similar completed projects with addresses of the project location, date of project completion, and contact information of the consultant firm of record, general contractor and owner.
4. Submit certification from a recognized testing agency that fire doors have passed tests to meet fire ratings indicated.
5. Certification from the Manufacturer stating that galvanizing has been completed in accordance with these specifications.
6. Certification from the Manufacturer stating that the rust-inhibitive primer is compatible with painting systems in Section 09 96 00 – High Performance Coatings.

C. Shop Drawings: Complete Shop Drawings showing location and detail of installation.

1. Shop Drawings shall be drawn to sufficient scale and shall include dimensions, show elevations and details of construction of each door and frame type, schedule of doors and frames, frame elevations and details, location and installation requirements for hardware, thickness of materials, joints, provisions for expansion and contraction, connections, accessories, and trim. Shop Drawings shall show installation conditions at openings with various wall thickness and materials.
2. Include details of core and edge construction, through-door louvers, vision panels, and trim for openings.

D. Samples:

1. The Contractor shall submit 2 samples of each of the following. Unless otherwise indicated, samples shall be full size and shall show gauges, configuration, construction, finish and color proposed for the various components. Samples shall be clearly marked to show the Manufacturer's name, product identification, finish and color. New samples shall be resubmitted of each, as required, until approved by the Engineer. Upon approval, the samples shall become the standard for acceptance for the project with regard to color, finish, and quality of each item. Approval of samples shall not relieve the Contractor from compliance with the Contract Documents.
2. 6-in by 6-in frame corner construction, including galvanizing, welding, grinding, touch-up, and priming.
3. 6-in by 6-in door panel construction, including galvanizing, welding, grinding, touch-up, and priming.

1.05 QUALITY ASSURANCE

A. Single Source Responsibility:

1. Steel doors and frames shall be provided by a single Manufacturer.

B. Steel doors and frames shall conform to ANSI A 250.8/SDI 100, except where more stringent requirements are indicated herein.

C. Fire Rated Openings:

1. Steel doors and frames required to be fire-rated shall bear UL labels indicating the applicable fire ratings. Designs and construction of such products shall have specific UL approval according to current procedures for the fire rating. Assemblies shall be constructed to comply with NFPA 80, with the Code, and with other requirements indicated.
2. Steel doors and frame assemblies and components shall be compliant with positive pressure and S-label requirements. Steel doors and frames shall be coordinated with door hardware supplier to ensure that total opening installation is compatible with UL 10C and NFPA 252.

PART 2 -- PRODUCTS

2.01 GENERAL

A. Structural Requirements:

1. Steel doors and frames, including related assemblies, components, and attachment details shall comply with the Code and shall be designed and installed for resistance to the structural design criteria indicated in the Contract Documents in accordance with the Code. Where a conflict occurs between the requirements of this Section and the Code, the more stringent shall apply.
 - a. Refer to Section 01 33 17 – Structural Design, Support and Anchorage for additional design criteria.

2. The Contractor shall provide additional non-standard bracing, reinforcements, anchors, and heavier gauge materials if required to conform to the structural design criteria indicated and to other performance requirements indicated.
- B. Refer to Section 08 71 00 – Door Hardware, for door hardware to be provided for Steel Doors and Frames.

2.02 STEEL DOORS

A. Manufacturer and Product, or Equal:

1. Subject to the requirements indicated, provide Manufacturer and product listed below:
 - a. Curries Co., (ASSA ABLOY Group); 747 Series modified by the Manufacturer with custom upgraded features as required to comply with the Specifications.
 - b. Steelcraft
 - c. Pioneer
 - d. Ceco

B. Description:

1. Provide flush design steel doors, 1 $\frac{3}{4}$ -in thick, seamless hollow construction, unless otherwise indicated.
2. Exterior Doors: 14-gauge galvanized sheet steel, SDI Level 4 Classification
3. Interior Doors: 16-gauge galvanized sheet steel, SDI Level 3-Model; 2 Classification
4. Galvanized steel sheets shall be zinc-coated carbon steel sheets of commercial quality, complying with ASTM A 653, G90 zinc coating, mill phosphatized.
5. For single-acting swing doors, vertical edge at lock edge shall be beveled 1/8-in in 2-in.
6. Doors shall be fabricated of 2 outer, galvanized, stretcher-leveled steel sheets not less than 16-gauge. Doors shall be constructed with smooth, flush surfaces without visible joints or seams on exposed faces or stile edges. Weep hole openings shall be provided in the bottom of doors to permit escape of entrapped moisture.
7. Inside of doors shall be reinforced with vertical galvanized sheet steel Sections not less than 22-gauge. Vertical reinforcing shall be spaced 6-in on center and extend full door height. Spot-weld at not more than 5-in on center to both face sheets.
8. Insulate spaces between door ribs with one pound, nominal density fiberglass insulation. R-value of door shall be at least 2.78 hr/Btu/sq. ft./deg F.
9. Tops and bottoms of doors shall be reinforced with 16-gauge horizontal steel channels welded continuously to outer sheets. Top and bottom edges shall be closed to provide seal, as integral part of door construction while providing recesses for required hardware and appurtenances.

HOLLOW METAL DOORS AND FRAMES

- C. Glazing: Comply with requirements in Section 08 81 00 – Glass Glazing.
- D. Through-Door Louvers: Provide through-door louvers of sizes indicated or required. Louvers shall be 18-gauge, cold-rolled galvanized steel sheet matching the doors. Fabricate units with stationary, sight-proof blades and channel shaped frames, not less than 1-in deep. Space louver blades not more than $\frac{3}{4}$ -in on center. Assemble units by welding.
- E. Transom Panels: Same materials and construction as indicated for exterior doors unless otherwise indicated.
- F. Door Hardware Reinforcement:
 - 1. Components shall be reinforced for hardware installation in accordance with ANSI/SDI A 250.6.
 - a. Lock and closer reinforcements shall be “box” or “channel” type.
 - b. Punch single leaf frames to receive 3 silencers. Double leaf frames shall receive one silencer per leaf at head.
 - c. Factory prepared hardware locations shall be in accordance with “Recommended Locations for Builders' Hardware for Standard Steel Doors and Frames,” as adopted by SDI.
 - d. Supply welded in mortar guards at hardware cutouts in frames built into masonry or grouted in full.

2.03 STEEL FRAMES

- A. Manufacturer and Product, or Equal:
 - 1. Subject to the requirements indicated, provide Manufacturer and product listed below, or equal:
 - a. Curries Co., (ASSA ABLOY Group); Masonry/Flush Frame M Type (Equal Rabbet).
- B. Description:
 - 1. Provide hollow metal frames for doors, windows, lites, cased openings, and for other openings where indicated. Frames shall be 14-gauge galvanized sheet steel, $5\frac{3}{4}$ - in wide by 2-in deep, unless otherwise indicated.
 - a. Stops shall be formed integral with the frame unless otherwise indicated.
 - b. Provide removable stops where indicated or required on secured room side of opening, formed of not less than 18-gauge steel sheets. Secure with oval head machine screws spaced uniformly not more than 12-in on center. Form corners with butted hairline joints.
 - 1) Coordinate width of rabbet between fixed and removable stops with type of glass, panel, and type of installation indicated.

- c. Galvanized steel sheets shall be zinc-coated carbon steel sheets of commercial quality, complying with ASTM A 653, G90 zinc coating, mill phosphatized.
 - 2. Frames shall be fabricated of welded unit construction, with corners mitered, reinforced, and face welded. No field-spliced frames will be allowed.
 - 3. Frames set in masonry walls are shall be face-welded and ground smooth and re-primed at the welded area.
 - 4. Provide temporary shipping bars to help protect from damage during transit and handling.
 - 5. Temporary shipping bars shall be removed before setting frames.
 - 6. Welds on frames shall be flush with neatly mitered or butted material cuts.
 - 7. Frames shall be pretreated prior to priming at factory by washing, phosphatizing and by chromic seal. Primer shall be baked on.
- C. Mullions and Transom Bars: Provide closed or tubular mullions and transom bars where indicated. Except where removable mullions or transom bars are indicated or required, fasten mullions and transom bars at crossings and to jambs by butt welding. Reinforce joints between frame members with concealed clip angles or sleeves of same metal and thickness as frame.
- 1. Where installed in masonry, leave vertical mullions in frames open at top for grouting.
- D. Jamb Anchors:
- 1. Masonry construction: Adjustable, flat, corrugated or perforated 'T' shaped with leg not less than 2-in wide by 10-in long or masonry "wire" type not less than 3/16-in diameter.
 - a. Provide at least 3 anchors equally spaced per jamb up to 7 ft 6-in in height. Provide 4 anchors equally spaced per jamb up to 8 ft in height, and one additional anchor equally spaced per jamb for each 24-in or fraction thereof over 8 ft in height.
 - 2. In-place masonry or concrete construction: Anchor frame jambs with minimum 3/8-in countersunk flat head stove bolt and expansion shields 6-in from top and bottom and 26-in on center, unless otherwise indicated.
 - a. Reinforce frames at anchor locations.
 - 1) Weld pipe spacers, or similar type spacers, per Manufacturer's standard design in back of frame soffit to protect frame profile during tightening of bolts and anchors.
 - b. Apply removable stop to cover anchor bolts where indicated.
 - 3. Provide UL approved fixed anchors at fire rated openings.
- E. Floor Anchors: Angle clip type.

1. 16-gauge minimum.
 2. 2 fasteners per jamb.
 3. Welded to the bottom of each jamb.
- F. Preparation for Hardware:
1. Reinforcement: Components shall be reinforced for hardware installation in accord with ANSI/SDI A250.6.
 2. Lock and closer reinforcements shall be "box" or "channel" type.
 3. Punch single leaf frames to receive 3 silencers. Double leaf frames shall receive one silencer per leaf at head.
 4. Factory prepared hardware locations shall be in accordance with "Recommended Locations for Builders' Hardware for Standard Steel Doors and Frames," as adopted by the SDI.
 5. Supply welded in mortar guards at hardware cutouts in frames built into masonry or grouted in full.
- G. Head Reinforcing: For frames over 4-ft 0-in wide in masonry wall openings, provide continuous steel channel or angle stiffener, not less than 12-gauge for full width of opening, welded to back of frame at head.
- H. Spreader Bars: Provide removable spreader bar across bottom of frames, tack welded to jambs and mullions.
- I. Plaster Guards: Provide 26-gauge galvanized steel plaster guards or dust cover boxes, welded to frame, at back of finish hardware cutouts where mortar or other materials might obstruct hardware installation.

2.04 FABRICATION

- A. The Contractor shall field verify size, location, and placement of doors and frames, shall advise the Engineer in writing of any necessary adjustments, and shall make the necessary adjustments prior to fabrication. The Contractor shall coordinate field measurements and Shop Drawings with fabrication and shop assembly to minimize field adjustments.
- B. Doors and frames shall be fabricated to be rigid, neat in appearance, and free from defects, including warping, cupping, buckling, or other defects. Metal shall be accurately formed to required sizes and profiles.
- C. Doors and frames shall be fit and assembled in the Manufacturer's plant. Weld exposed joints continuously; grind, dress, and make smooth, flush, and invisible. Metallic filler to conceal manufacturing defects is not acceptable.
- D. Doors and frames shall be prepared to receive mortised and concealed door hardware, including cutouts, reinforcing, drilling, and tapping in accordance with final Door Hardware Schedule and templates provided by hardware supplier, and as indicated in the Contract Documents.

1. Comply with applicable requirements of ANSI A 115 for preparation for hardware on doors and frames.
 2. Include thru-bolting holes as required per hardware template.
 3. Do not include unnecessary cutouts in door faces not required by hardware template.
 4. Doors and frames shall be reinforced to receive surface-applied hardware. Drilling and tapping for surface-applied door hardware may be done at Site.
- E. Shop Surface Preparation and Priming:
1. Steel surfaces shall be cleaned of dust, dirt, mill scale, rust, oil, grease, and other foreign materials.
 - a. Zinc-rich primer shall be applied to damaged galvanized surfaces.
 2. Pretreatment shall be applied to cleaned metal surfaces, using cold phosphate solution or hot phosphate solution.
 3. One full shop coat of rust-inhibitive primer shall be applied within time limits recommended by pretreatment Manufacturer. A smooth coat of even consistency shall be applied to provide a uniform dry film thickness of not less than 2.0 mils.
- F. Zinc-Rich Touch-up Primer: Use 95 percent metallic zinc dust primer in a vehicle compatible with the epoxy painting systems in Section [[[09 96 00]]] [[09960]] – High Performance Coatings.
- G. Supports and Anchors: Fabricate of not less than 16-gauge sheet metal. Galvanize after fabrication units complying with ASTM A 153, Class B.
- H. Inserts, Bolts, and Fasteners: Hot-dip galvanize, complying with ASTM A 153, Class C or D, as applicable.
- I. Rust-Inhibitive Primer:
1. Air-drying or baking type compatible with epoxy finish paint in Section 09 96 00 – High Performance Coatings.
 2. Provide non-standard primer if required to obtain compatibility.
- J. Steel doors and frames shall be field painted per Section 09 96 00 – High Performance Coatings.

PART 3 -- EXECUTION

3.01 DELIVERY, STORAGE, AND HANDLING

- A. Deliver materials to Site in Manufacturer's original, unopened packages, containers, or bundles with labels intact, which clearly identify contents.
1. Steel doors and frames shall be shipped and stored with temporary stiffeners and spacers in place to prevent distortion.

- B. Store materials carefully in accordance with the Manufacturer's written instructions, in an area that is protected from deleterious elements, and in a manner that will prevent damage to the products.
- C. Handle materials in strict accordance with Manufacturer's written instructions.

3.02 PROJECT CONDITIONS

- A. Comply with Manufacturer's written instructions for environmental conditions before, during, and after installation.
- B. Protect surrounding Work from damage that may result from operations under this Section.

3.03 INSPECTION

- A. The Contractor shall be totally responsible for the proper performance and completion of the Work under this Section.
- B. Systems and components shall be inspected before installation.
 - 1. Damaged or defective items shall be rejected and marked as such and shall be removed from the Site.
 - 2. Exposed surfaces that exhibit pitting, seam marks, roller marks, stains, discoloration, or other surface imperfections on the finished units shall be rejected.
- C. The Contractor shall verify dimensions, tolerances, and method of attachment with adjacent Work.
 - 1. Examine substrates, areas, and conditions where doors and frames will be installed for compliance with the requirements for installation, taking into account tolerances, and other conditions affecting performance of installed doors and frames.
 - a. Provide inserts, backing, blocking, anchoring devices, and reinforcements that must be built into other Work for the installation of steel doors and frames. Coordinate delivery with other Work to avoid delay.
 - 2. Notify the Engineer in writing of conditions detrimental to the proper and timely completion of the Work. Do not proceed with the Work until unsatisfactory conditions have been corrected in an acceptable manner.
 - 3. Commencement of the installation by the Contractor shall indicate Contractor's acceptance of the substrate, areas, and conditions.

3.04 PREPARATION

- A. Sequence installation properly with the installation and protection of other Work, so that neither will be damaged by the installation of the other.

3.05 INSTALLATION

- A. Installation shall comply with the requirements of the Contract Documents, with applicable references, with the requirements of the Code, and with Manufacturer's written instructions. Where a conflict occurs among these requirements, the more stringent shall apply, as directed by the Engineer.
- B. The Contractor shall provide corrosion resistant fasteners, anchors, and shims required for a complete installation, and shall be secure, plumb, level, straight, and true to line, allowing for required movement, including expansion and contraction.
- C. The Contractor shall provide separation of dissimilar materials to ensure no galvanic action occurs.
- D. The Contractor shall block and reinforce walls as required to support the Steel Doors and Frames and appurtenances.
- E. Setting Masonry Anchorage Devices: Provide masonry anchorage devices where required for securing frames to in-place concrete or to existing masonry construction. Set anchorage devices opposite each anchor location, in accordance with details on Shop Drawings and anchorage device Manufacturer's instructions. Drilled holes shall be left rough, not reamed and free from dust and debris.
- F. Glazing: Comply with installation requirements in Section 08 81 00 - Glass Glazing and with hollow-metal manufacturer's written instructions.
- G. Placing Frames: Set frames accurately in position, plumbed, aligned, and braced securely until permanent anchors are set. After wall construction is complete, remove temporary braces and spreaders leaving surfaces smooth and undamaged.
- H. In new masonry construction, coordinate frame setting with and prior to the building of masonry walls. Provide the required anchors for building in place.
- I. At in-place concrete or masonry construction, set frames and secure in place with machine screws and masonry anchorage devices.
- J. Remove spreader bars only after frames or bucks have been properly set and secured.

3.06 CLEANING, FINISHING, AND PROTECTION

- A. Adhesive papers used for masking which become firmly bonded when exposed to heat and/or light shall not be used.
 - 1. Remove masking film and temporary labels as soon as possible after installation. Films and labels left in place after installation shall be the responsibility of the Contractor.
 - 2. Residue shall not be left on any surfaces.
- B. Upon completion of the installation, doors and frames and appurtenances shall be cleaned of dirt and other foreign matter to the satisfaction of the Engineer.
 - 1. Cleaning shall be performed again immediately prior to acceptance of the Work, when directed by the Engineer.

2. Cleaning shall be performed in accordance with the Manufacturer's written instructions.
- C. Adjusting and cleaning shall consist of ensuring smooth operation, lubricating and testing the doors and frames.
 1. Doors and frames shall operate smoothly, quietly, and without squeaking and binding.
- D. Immediately after installation, sand smooth any rusted or damaged areas of prime coat and apply touch-up of compatible air-drying primer.
- E. Doors and frames shall be protected from damage from subsequent construction operations.
- F. The Contractor shall make adjustments required and retest until accepted.
- G. The Contractor shall remove scratches and blemishes to the satisfaction of the Engineer.
- H. Damaged or defective items shall be removed and replaced at the direction of the Engineer.
 1. Remove and replace defective Work, including doors or frames that are warped, bowed, or otherwise unacceptable.
- I. When door and frame Work is completed, remove unused materials, containers, and equipment, and clean the Site of door and frame debris.

END OF SECTION

SECTION 08 23 00 – OVERHEAD COILING DOORS

PART 1 -- GENERAL

1.01 SUMMARY

A. Section Includes:

1. Overhead coiling doors with operating assemblies, curtains, guides, hardware, and accessories as required for complete, operational installation.

1.02 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

A. Reference Specifications

01 33 00	Submittal Procedures
01 33 17	Structural Design, Support and Anchorage

B. Reference Standards

ASTM International (ASTM)	
ASTM A123	Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel
ASTM A153	Zinc Coating (Hot-Dip) on Iron and Steel Hardware
ASTM A653.	Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process
ASTM D3363	Standard Test Method for Film Hardness by Pencil Test.

1. Building Code: Refer to the Drawings to determine which Building Code applies. The applicable Building Code, defined by the Drawings, is referenced herein as “the CODE”.
2. Enclosures intended for indoor or outdoor use primarily to provide a degree of protection against corrosion, windblown dust and rain, splashing water, and hose-directed water.

1.03 SUBMITTALS

A. Furnish submittals in accordance with Section 01 33 00 – Submittal Procedures.

1.04 ACTION SUBMITTALS

A. Product Data:

1. Manufacturer’s specifications, technical data, installation methods, and maintenance instructions, and the following:
 - a. Complete operation instructions.
 - b. Manufacturer’s full-range color charts, indicating custom color availability for color selection by the Owner.
2. Certificates:

OVERHEAD COILING DOORS

3. Certification by the overhead coiling door Manufacturer that the overhead coiling doors provided are suitable for, and compatible with, the required installation.
4. When requested by the Engineer, furnish other certifications as may be required to show compliance with the Contract Documents.

B. Shop Drawings and Calculations:

1. Complete Shop Drawings showing location and detail of installation, and design calculations.
2. Shop Drawings and Calculations shall be prepared, approved, and stamped by a professional structural engineer licensed per local engineering laws.
3. Shop Drawings shall be drawn to sufficient scale and shall include dimensions, show elevations and details of construction of each overhead coiling door type, schedule of overhead coiling doors, location and installation requirements for hardware, thickness of materials, joints, provisions for expansion and contraction, connections, accessories, and trim. Shop Drawings shall show installation conditions at openings with various wall thickness and materials.
 - a. Shop Drawings shall include material descriptions, door guides, finish, color, details of construction, installation, accessories, and operation of each overhead coiling door type.

C. Samples:

1. The Contractor shall submit 2 samples of each of the following. Unless otherwise indicated, samples shall be full size and shall show gauges, configuration, construction, finish and color proposed for the various components. Samples shall be clearly marked to show the Manufacturer's name, product identification, finish and color. New samples shall be resubmitted of each, as required, until approved by the Engineer. Upon approval, the samples shall become the standard for acceptance for the project with regard to color, finish, and quality of each item. Approval of samples shall not relieve the Contractor from compliance with the Contract Documents.
2. 3-in by 4-in color samples showing substrate, finish, and color.

1.05 CLOSEOUT SUBMITTAL

A. Warranty:

1. Submit a copy of the warranty.

1.06 QUALITY ASSURANCE

A. Single Source Responsibility:

1. Overhead coiling doors shall be provided by a single Manufacturer.

B. Qualifications:

1. Manufacturers:

- a. Overhead coiling doors Manufacturer shall have a minimum of 5 similar successful projects over the most recent 10 years, employing similar products, materials, applications, and performance requirements.
2. Installers:
 - a. Installer shall be trained, certified, and authorized by the Manufacturer to install the Manufacturer's product.

1.07 WARRANTY

A. Manufacturer Warranty:

1. For overhead coiling door and appurtenances furnish Manufacturer's 2-year written warranty to cover defects in materials, products, and manufacturing workmanship.
2. The Contractor shall furnish separate, but concurrently running, 2-year written warranty to cover labor.
3. Warranties shall be non-prorated for the entire warranty period.
4. The term of the warranties shall begin on the date of Substantial Completion.

PART 2 -- PRODUCTS

2.01 GENERAL

A. Structural Requirements:

1. Overhead coiling doors, including related assemblies, components, and attachment details shall comply with the CODE and shall be designed and installed for resistance to the structural design criteria indicated in the Contract Documents in accordance with the CODE. Where a conflict occurs between the requirements of this Section and the CODE, the more stringent shall apply.
 - a. Refer to Section 01 33 17 – Structural Design, Support and Anchorage for additional design criteria.
2. The Contractor shall provide additional non-standard bracing, reinforcements, anchors, and heavier gauge materials in order to conform to the structural design criteria indicated and to other performance requirements indicated.

B. Design Requirements:

1. The Contractor shall furnish professional design and engineering services as required for overhead coiling doors.
 - a. Professional design and engineering services may be provided by the Manufacturer or by an independent licensed civil engineer retained by the Contractor, either of which shall comply with the requirements indicated.
2. The Contractor shall coordinate color samples with other Sections through the submittal process.

2.02 OVERHEAD COILING DOORS

A. Manufacturers and Products:

1. Subject to the requirements indicated, provide Manufacturer and product listed below.
 - a. **Cornell Iron Works, Inc.; Thermiser ESD20 & ESD20W** – With Additional Options and Custom Features as specified herein.
 - b. The Cookson Company; Temp-Pro Rolling Service Door.
 - c. Wayne Dalton; Thermotite Model 800C

B. Description:

1. Overhead coiling doors shall be insulated slat, interior mounted, manual operated, with factory applied finish and color as indicated.
 - a. Steel Doors: Interlocking slats of galvanized steel skins conforming to Grade 40 galvanized steel zinc coating, in accordance with ASTM A653. Each slat shall be formed of exterior 20-gauge, interior 24-gauge, galvanized steel sheets.
2. Fabricate interlocking sections with end-locks on slats to maintain slat alignment, prevent wear, and to comply with requirements.

C. Insulation:

1. 7/8-in foamed in place, closed cell polyurethane insulation enclosed in each slat.
2. Total slat R-value: 8.0 hr/Btu/sq ft/deg F minimum.

D. Bottom Bar:

1. Reinforced extruded aluminum interior face with full depth insulation and exterior skin slat to match curtain material and gauge.
2. Finish and color of interior and exterior surfaces shall match slats.
3. Provide with Manufacturer's standard cylinder lock option.

E. Guides:

1. Minimum of 3/16-in galvanized structural steel and with sufficient depth to retain the curtains in the guides against the design loads. Provide aluminum guides for aluminum doors.
2. When wind-locks are necessary in order to comply with the requirements, provide wind-lock bars of same material as the guides.
3. Provide removable guide stoppers to prevent over-travel of curtain and bottom bar.
4. For steel door guides only – Top 16 1/2-in of coil side guide angles shall be removable for ease of door installation and as needed for future door service.

5. Provide wind-locks of same material to comply with requirements.
 6. Provide a padlockable chain keeper on guide.
- F. Counterbalance, Brackets, and Hood:
1. Fabricated in accordance with the Manufacturer's standard practice.
 2. The coil shall be housed in a 24-gauge galvanized steel sheet metal hood with reinforced top and bottom edges.
 3. Provide minimum 1/4-in steel intermediate-support brackets as required to prevent excessive sag.
 4. Finish shall match the slats.
- G. Weatherstripping:
1. Bottom bar: provide weatherseal neoprene extending full width of door.
 2. Guides: Provide replaceable vinyl strip sealing against fascia side of door.
 3. Lintel: provide nylon brush seal fitted at door header to impede airflow.
 4. Hood: provide neoprene / rayon baffle to impede airflow above coil.
- H. Locking: Pad-lockable slide bolt on fascia side of bottom bar at each jamb extending into slots in guides.

2.03 FINISH AND COLOR

A. Steel Components:

1. Galvanizing:
 - a. Sheet steel shall be provided with a zinc coating at not less than 0.90-oz/sq-ft of steel and in a manner as to provide a ductile coating, tightly adhered to base metal and conforming to bond tests converted in accordance with ASTM A 653.
 - b. Structural shapes and similar heavy steel shall be hot-dipped galvanized per ASTM A123 and ASTM A153, as applicable. Provide phosphate coating for paint adhesion at the factory.

B. Steel Door Finish:

1. Provide Manufacturer's fusion bonded thermosetting powder coat finish applied to a minimum 2.5 mils cured film thickness.
2. Pencil hardness to be rated H or better per ASTM D3363.

C. Color:

1. Color shall be selected and approved by the Owner from Manufacturer's full color range including custom colors and may be required to exactly match other building components, as determined by the Owner.

a. Tentative color selection: To be selected from manufacturer's available colors.

- 1) The Owner reserves the option of changing this tentative color selection during the submittal process.

2.04 OPERATION

- A. Manual ControlGard Chain Hoist: Provide chain hoist operator with endless steel chain, chain pocket wheel and guard, geared reduction unit, and chain keeper secured to guide. Chain hoist to
- B. include integral brake mechanism that will immediately stop upward or downward travel and maintain the door in a stationary position when the hand chain is released by the user.

2.05 FABRICATION

- A. The Contractor shall field verify size, location, and placement of overhead coiling doors, shall advise the Engineer in writing of any necessary adjustments, and shall make the necessary adjustments prior to fabrication. The Contractor shall coordinate field measurements and Shop Drawings with fabrication and shop assembly to minimize field adjustments.
 1. Overhead coiling doors shall be assembled before shipment to the Site.

PART 3 -- EXECUTION

3.01 DELIVERY, STORAGE, AND HANDLING

- A. Deliver materials to Site in Manufacturer's original, unopened packages, containers, or bundles with labels intact, which clearly identify contents.
- B. Store materials carefully in accordance with the Manufacturer's written instructions, in an area that is protected from deleterious elements, and in a manner that will prevent damage to the products.
- C. Handle materials in strict accordance with Manufacturer's written instructions.

3.02 PROJECT CONDITIONS

- A. Comply with Manufacturer's written instructions for environmental conditions before, during, and after installation.
- B. Protect surrounding Work from damage that may result from operations under this Section.

3.03 INSPECTION

- A. The Contractor shall be totally responsible for the proper performance and completion of the Work under this Section.
- B. Systems and components shall be inspected before installation.
 1. Damaged or defective items shall be rejected and marked as such and shall be removed from the Site.

2. Exposed surfaces that exhibit pitting, seam marks, roller marks, stains, discoloration, or other surface imperfections on the finished units shall be rejected.
- C. The Contractor shall verify dimensions, tolerances, and method of attachment with adjacent Work.
1. Examine substrates, areas, and conditions where doors and appurtenances will be installed for compliance with the requirements for installation, taking into account tolerances, and other conditions affecting performance of installed doors and appurtenances.
 - a. Provide inserts, backing, blocking, anchoring devices, and reinforcements that must be built into other Work for the installation of overhead coiling doors. Coordinate delivery with other Work to avoid delay.
 2. Notify the Engineer in writing of conditions detrimental to the proper and timely completion of the Work. Do not proceed with the Work until unsatisfactory conditions have been corrected in an acceptable manner.
 3. Commencement of the installation by the Contractor shall indicate Contractor's acceptance of the substrate, areas, and conditions.

3.04 PREPARATION

- A. Sequence installation properly with the installation and protection of other Work, so that neither will be damaged by the installation of the other.

3.05 INSTALLATION

- A. Installation shall comply with the requirements of the Contract Documents, with applicable references, with the requirements of the CODE, and with Manufacturer's written instructions. Where a conflict occurs among these requirements, the more stringent shall apply, as directed by the Engineer.
- B. The Contractor shall provide corrosion resistant fasteners, anchors, and shims required for a complete installation, and shall be secure, plumb, level, straight, and true to line, allowing for required movement, including expansion and contraction.
- C. The Contractor shall provide separation of dissimilar materials to ensure no galvanic action occurs.
- D. The Contractor shall block and reinforce walls as required to support the overhead coiling doors and appurtenances.
- E. Horizontal lines shall be level, and vertical lines shall be plumb.
- F. Anchors for guides, brackets, and other fasteners shall be provided as required.

3.06 CLEANING, FINISHING, AND PROTECTION

- A. Adhesive papers used for masking which become firmly bonded when exposed to heat and/or light shall not be used.

1. Remove masking film and temporary labels as soon as possible after installation. Films and labels left in place after installation shall be the responsibility of the Contractor.
 2. Residue shall not be left on any surfaces.
- B. Upon completion of the installation, overhead coiling doors and appurtenances shall be cleaned of dirt and other foreign matter to the satisfaction of the Engineer.
1. Cleaning shall be performed again immediately prior to acceptance of the Work, when directed by the Engineer.
 2. Cleaning shall be performed in accordance with the Manufacturer's written instructions.
- C. Adjusting and cleaning shall consist of ensuring smooth operation, lubricating and testing the overhead coiling doors and appurtenances.
1. Overhead coiling doors shall operate smoothly, quietly, and without squeaking and binding.
- D. Overhead coiling doors shall be protected from damage from subsequent construction operations.
- E. The Contractor shall make adjustments required and retest until accepted.
- F. The Contractor shall remove scratches and blemishes to the satisfaction of the Engineer.
- G. Damaged or defective items shall be removed and replaced at the direction of the Engineer.
- H. When overhead coiling doors Work is completed, remove unused materials, containers, and equipment, and clean the Site of overhead coiling doors debris.

END OF SECTION

SECTION 08 71 00 – DOOR HARDWARE

PART 1 -- GENERAL

1.01 SUMMARY

A. Section Includes:

1. Door hardware

1.02 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

A. Where reference is made to any of the below, the revision in effect at the time of bid opening shall apply.

B. Reference Specifications

01 33 00	Submittal Procedures
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C. Reference Standards

Americans with Disabilities Act (ADA)	
ADAAG	Americans with Disabilities Accessibility Guidelines
American National Standards Institute (ANSI)	
ANSI A 117.1	Accessible and Usable Buildings and Facilities
ANSI A 156.1	Butts and Hinges
ANSI A 156.3	Exit Devices
ANSI A 156.4	Door Controls – Door Closers
ANSI A 156.5	Auxiliary Locks and Associated Products
ANSI A 156.6	Architectural Door Trim
ANSI A 156.7	Template Hinge Dimensions
ANSI A 156.8	Door Controls – Overhead Stops
ANSI A 156.13	Mortise Locks and Latches
ANSI A 156.15 -	Closer Holder Release Devices
ANSI A 156.16	Auxiliary Hardware
ANSI A 156.18	Material and Finishes
ANSI A 117.1	Accessible and Usable Buildings and Facilities
Builders' Hardware Manufacturers' Association (BHMA)	
Building Code	
	Refer to the Drawings to determine which Building Code applies. The applicable Building Code, defined by the Drawings, is referenced herein as "the Code"
Door and Hardware Institute (DHI)	
	Recommended Procedure for Processing Hardware Schedules and Templates" and "Architectural Hardware Scheduling and Format.

DOOR HARDWARE

National Fire Protection Association (NFPA)	
NFPA 80	Fire Doors and Windows
NFPA 101	Life Safety Code
Underwriters' Laboratories (UL)	
UL 10B	Standard for Fire Test Door and Assemblies
UL 10C	Positive Pressure Fire Tests of Door Assemblies

1.03 SUBMITTALS

A. Furnish submittals in accordance with Section 01 33 00 – Submittal Procedures.

1.04 ACTION SUBMITTALS

A. Product Data:

1. Manufacturer's specifications, technical data, installation methods, and maintenance instructions.

B. Certificates:

1. Certification by the door hardware Manufacturer that the door hardware provided is suitable for, and compatible with, the required installation.
2. Certification of Manufacturer qualifications demonstrating compliance with the qualifications requirements indicated. Include a list of 5 similar completed projects with addresses of the project location, date of project completion, Manufacturer's products, and contact information of the consultant firm of record, general contractor and owner.
3. Certification of supplier's qualifications demonstrating compliance with the qualifications requirements indicated.
4. Certification of installer qualifications demonstrating compliance with the qualifications requirements indicated. Include a list of 5 similar completed projects with addresses of the project location, date of project completion, and contact information of the consultant firm of record, general contractor and owner.
5. Submit certification from a recognized testing agency that fire doors have passed tests to meet fire ratings indicated.
6. Certification for hardware in fire rated openings indicating compliance with UL 10C and the Code.
7. When requested by the Engineer, furnish other certifications as may be required to show compliance with the Contract Documents.

C. Shop Drawings:

1. Complete Shop Drawings showing location and detail of installation.

2. Furnish a complete, detailed hardware schedule. The hardware schedule shall indicate groups, type, style, function, Manufacturer's name, catalog number, location, and finish of each item to be provided, in accordance with the DHI "Architectural Hardware Scheduling Sequence and Format." The hardware schedule shall include the following additional information:
 - a. List each door opening, organized into "hardware sets" indicating complete designations of every item required for each door opening to function as intended.
 - b. Location of each hardware set cross-referenced to floor plans and schedules on the Drawings.
 - c. Door sizes shall be noted on the hardware schedule, and hardware shall be in strict accordance with height, width, and thickness requirements.
 - d. Special mounting instructions or requirements that vary from standard.
 - e. Handing and degree of swing of each door.
 - f. Keying information.
 - g. Fastenings and other pertinent information.
 - h. Explanation of all abbreviations, symbols, and codes contained in schedule.
 - i. The hardware schedule shall also include a complete template list showing template references and data for each item requiring preparation of doors and frames.
 - j. Submit separate detailed keying schedule for approval indicating clearly how the Owner's final instructions on keying of locks has been fulfilled.

D. Samples:

1. When requested by the Engineer, submit samples of the materials proposed. Samples shall be clearly marked to show the Manufacturer's name, product identification, finish and color. New samples shall be resubmitted of each, as required, until approved by the Engineer. Upon approval, the samples shall become the standard for acceptance for the project with regard to color, finish, and quality of each item. Approval of samples shall not relieve the Contractor from compliance with the Contract Documents.

1.05 CLOSEOUT SUBMITTALS

A. Warranty:

1. Submit a copy of the warranty.

1.06 QUALITY ASSURANCE

A. Single Source Responsibility:

1. Door hardware shall be provided by a single Manufacturer, each.

B. Qualifications:

1. Manufacturers:

- a. Door hardware Manufacturer shall have a minimum of 20 years of door hardware manufacturing experience.
- b. Door hardware Manufacturer shall have a minimum of 5 similar successful projects over the most recent 10 years, employing similar products, materials, applications, and performance requirements.
- c. Manufacturers without these qualifications will not be accepted.

2. Suppliers:

- a. Supplier shall be a recognized architectural door hardware supplier who has maintained an office and has been furnishing hardware in the project's vicinity for a period of at least 2 years.
- b. Supplier shall employ at least one Architectural Hardware Consultant (AHC) who shall be responsible for the preparation and execution of the Work of this Section and who shall be available to the Owner, the Engineer, and the Contractor during business hours for consultation about the project's hardware and requirements.
- c. Supplier shall be a certified direct distributor and be a full sales and service organization for the Manufacturers proposed.
- d. Suppliers without these qualifications will not be accepted.

3. Installers:

- a. Installer shall have a minimum of 5 years' experience in the successful completion of at least 5 projects of similar size and scope, employing similar products, materials, applications, and performance requirements.
- b. Installer shall be trained, certified, and authorized by the Manufacturer to install the Manufacturer's product.
- c. Installers without these qualifications will not be accepted.

1.07 WARRANTY

A. Manufacturer Warranty:

- 1. Furnish Manufacturer's written warranty to cover defects in materials, products, and manufacturing workmanship. The term of the warranty shall be as indicated below:
 - a. Mortise Locksets: 5 years.
 - b. Exit Devices: 5 years.
 - c. Door Closers: 10 years.

2. The Contractor shall furnish separate, but concurrently running, 5-year written warranty to cover labor.
3. Warranties shall be non-prorated for the entire warranty period.
4. The term of the warranties shall begin on the date of Substantial Completion.

PART 2 -- PRODUCTS

2.01 GENERAL

- A. Door hardware shall be recommended by the Manufacturer for the installation indicated.
- B. Door hardware shall be suitable for, and compatible with, the required installation.
- C. Door hardware shall be best grade, entirely free from imperfections in manufacture and finish. Qualities, weights, and sizes specified herein are the minimum that will be accepted.
- D. Hand of door shall be as indicated. If door handing changes prior to fabrication, the Contractor shall make necessary adjustments at the direction of the Engineer.
- E. The Work hereunder shall include fabrication and mounting templates as needed for fabricators and for control of application of hardware items.
 1. In addition thereto, the Contractor shall provide trim, attachments, and fastenings indicated or required for proper and complete installation.
- F. Door hardware shall be coordinated with other Work requiring door hardware or attaching to it. Copies of schedules, templates, etc., shall be furnished in ample time to avoid fabrication and construction delays. Each item of hardware shall be identified according to the approved list and schedule. Hardware shall be made to template.
- G. The Contractor shall furnish the hardware supplier with Shop Drawings from other trades with which hardware must be coordinated. After checking these Shop Drawings, the Contractor shall promptly supply necessary template information to all concerned as may be required to facilitate the progress of the job.
 1. Furnish all templates and schedules required by the Manufacturers of the doors and frames to enable the Manufacturers to make proper provision in their Work to receive the door hardware. All locks, lock strikes, and flush bolts shall be made to ANSI standard dimensions.
 2. Procedures for template information shall be in accordance with the handbook, "Recommended Procedure for Processing Hardware Schedules and Templates."

2.02 FIRE RATED OPENINGS

- A. Hardware furnished in connection with doors bearing UL Labels or where necessary to meet special requirements shall be in strict accordance with the Code and shall be subject to approval of the authority having jurisdiction.

- B. Provide door hardware for fire-rated openings that comply with NFPA 80 and requirements of authorities having jurisdiction. Provide only items of door hardware that are listed by Underwriters Laboratories Inc. (UL) for use on types and sizes of doors indicated.
 - 1. UL labeled doors shall have UL approved hardware, except that hinges that are not UL approved shall have a melting point greater than 2,000 deg F.
 - 2. Certifications of compliance shall be made available to the Authority Having Jurisdiction upon request.
- C. Door assemblies and components shall be compliant with positive pressure and S-label requirements. Door hardware shall be coordinated with door Manufacturers to ensure that total opening installation is compatible with UL 10C and the Code.

2.03 HINGES

A. Manufacturer or Equal:

- 1. Subject to the requirements indicated, provide products from the Manufacturer listed below, or equal.
 - a. McKinney.
 - b. Pemko.

B. Description:

- 1. Hinges shall conform to ANSI A 156.1/BHMA A 2111 and shall be 5-knuckle design, heavy weight (0.180-in minimum), ball bearing type, with flush tips.
- 2. Two hinges shall be provided for each door leaf up to and including 5-feet (1.5 m) in height and an additional hinge shall be added for each 2½-feet (.76 m) or fractions thereof of additional door height.
- 3. Hinges shall be 4½ in by 4½-in, except at doors exceeding 36-in in width.
 - a. Doors exceeding 36-in in width shall have 5-in by 4½-in hinges.
- 4. Hinges on exterior doors shall be provided with non-removable pins (NRP).
- 5. Provide hinges with countersunk, Phillips flat-head screws unless otherwise indicated.

2.04 CYLINDERS AND KEYING

A. Manufacturer and Product, or Equal:

- 1. Subject to the requirements indicated, provide Manufacturer and product listed below, or equal:
 - a. Sargent, Signature High Security Cylinders

B. Description:

1. Locks and cylinders shall be master keyed to the Owner's requirements as directed by the Engineer.
2. The Contractor shall have the hardware supplier submit a keying schedule for approval prior to placing an order for the locks and keying of cylinders. The keying schedule shall be coordinated between the Owner, the Engineer, the Contractor, and the hardware supplier.

C. Keying:

1. Locks and cylinders shall be construction master-keyed. Locks and cylinders to be master-keyed or grandmaster-keyed as directed by the Owner. The factory shall key locks and cylinders. Furnish the following key amounts:
 - a. 2 change keys per lock.
 - b. 3 grand master keys.
 - c. 6 master keys per master level.
 - d. 6 construction/temporary keys.
2. Master keys and all high-security or restricted keyway blanks shall be sealed in tamper-proof packaged boxes when shipped from the factory. The boxes shall be shrink-wrapped and imprinted to ensure the integrity of the packaging.

2.05 SURFACE MOUNTED OVERHEAD CLOSERS

A. Manufacturer and Product, or Equal:

1. Subject to the requirements indicated, provide Manufacturer and product listed below, or equal:
 - a. Sargent 351 Series.

B. Description:

1. Closers shall be ANSI A 156.4, Grade 1 Certified.
2. Closers shall have non-ferrous covers, one-piece, aluminum alloy bodies forged steel arms, and separate valves for adjusting and backcheck, closing and latching cycles, and adjustable spring to provide up to 50 percent increase in spring power.
3. Closers shall be furnished with parallel arm mounting on doors and shall be mounted to permit 180-degree door swing wherever wall conditions permit. Furnish without hold open arms unless otherwise indicated. Closers shall not be installed on exterior or corridor side of doors; install closers on door unless otherwise approved in writing by the Engineer.
4. Closers shall be powder coated to match door hardware with a special rust inhibitor (SRI) pretreatment, as recommended in writing by the Manufacturer, applied prior to the powder coating.
5. Where closers or other items have lever or similar arms, attachment to doors shall be with sex bolts only.

6. Closers for out-swinging exterior doors shall be top-jamb-mounted and furnished with adapter plates.
7. The Contractor shall be responsible to provide the correct arm with the closers.
8. Closers shall be provided with sex bolts for fastening through doors, frames and transoms.

2.06 MORTISE LOCKSETS AND LATCHSETS

A. Manufacturer and Product, or Equal:

1. Subject to the requirements indicated, provide Manufacturer and product listed below, or equal:
 - a. Sargent 8200 Series.

B. Description:

1. Locksets shall be ANSI A 156.13 Series 1000 Grade 1. Functions shall be manufactured in a single sized case formed from minimum 12-gauge steel. Lockset shall have a field-adjustable, beveled armored front, with a 0.125-in (3.2 mm) minimum thickness and shall be reversible without opening the lock body. The lockset shall be 2 ¾-in backset with a one-piece ¾-in anti-friction stainless steel latchbolt. The deadbolt shall be a full 1-in throw made of stainless steel and have two hardened steel roller inserts. To ensure proper alignment, all trim, shall be thru-bolted and fully interchangeable between rose and escutcheon designs.
2. Function of locksets shall be appropriate for doors use. Hardware supplier shall verify lock functions with the Owner and the Engineer prior to ordering material.
3. Lock strikes shall be non-handed, boxed type of sufficient length and having curved lips to protect the trim and jambs and be so shaped as to avoid the possibility of tearing clothing. Strikes shall be provided with metal strike boxes.
4. Locks shall be provided with the same cylinder and keyway for master keying. They shall be the product of the same Manufacturer as the locksets unless otherwise indicated. The correct cylinders with necessary modifications and components such as cams, collars, rings, retainers, plates, fasteners, etc., shall be provided for other specialty hardware such as exit devices, store front locksets, and sliding door locks where the hardware manufacture specified is different than cylinder Manufacturer.
5. Exit doors shall be openable at all times from the inside without the use of key or any special knowledge or effort.

2.07 STRIKES

A. Manufacturer:

1. To be provided by exit device and lockset and latchset device Manufacturer.

B. Description:

1. Strikes shall be compatible with the installation required.

2. All strikes shall be non-handed with a curved lip.

2.08 EXIT DEVICES

A. Manufacturer and Product, or Equal:

1. Subject to the requirements indicated, provide Manufacturer and product listed below, or equal:
 - a. Sargent, 80 Series.

B. Description:

1. Exit devices shall be certified to meet ANSI A 156.3 Grade 1.
2. Exit devices shall be listed by Underwriters Laboratories and shall bear the UL label for life safety in full compliance with NFPA 80 and NFPA 101.
3. Mounting rails shall be formed from a solid single piece of stainless steel, brass, or bronze no less than 0.072-in thick. Push rails shall be constructed of 0.062-in thick material. Painted or anodized aluminum shall not be considered heavy duty and are not acceptable. Hex key dogging shall be standard for all life safety panic hardware. Lever trim shall be available in finishes and designs to match that of the specified locksets.

2.09 LOCK GUARDS

A. Manufacturer, or Equal:

1. Subject to the requirements indicated, provide products from the Manufacturer listed below, or equal.
 - a. McKinney.

B. Description: Provide high security, corrosion resistant, surface mounted lock guards with concealed fasteners compatible with the installation, at each exterior door.

2.10 DOOR TRIM AND PROTECTIVE PLATES

A. Manufacturer, or Equal:

1. Subject to the requirements indicated, provide products from the Manufacturer listed below, or equal.
 - a. McKinney.
 - b. Pemko.

B. Description:

1. Kickplates shall be 0.050-gauge, 2-in less width of door, beveled on 3 sides, and 10-in high, except where necessary to clear a louver in which case they shall be 8-in high.

2. Push plates, pull plates, door pulls, and miscellaneous door trim shall be as indicated.

2.11 WALL MOUNTED DOOR STOPS

A. Manufacturer, or Equal:

1. Subject to the requirements indicated, provide products from the Manufacturer listed below, or equal.
 - a. McKinney.

B. Description:

1. Where a door is indicated to open against a wall, wall mounted doorstops, in the form of wall bumpers, shall be provided. Provide convex or concave design as indicated.
2. Wall mounted doorstops shall be non-ferrous, and of the type given in the hardware schedule.
3. Provide door stops with the proper fasteners, as required by the substrate to which stops are to be secured.

2.12 OVERHEAD STOPS WITH HOLD OPEN FUNCTION

A. Manufacturer, or Equal:

1. Subject to the requirements indicated, provide products from the Manufacturer listed below, or equal:
 - a. Rixson.

B. Description:

1. Overhead type door holders shall be of correct size for door, 90 degree openable and allowing for checkmating. Interior doors shall be provided with overhead stops if wall type stops cannot be used.
2. Track, slide, arm, and jamb bracket shall be constructed of extruded bronze and shock absorber spring shall be of heavy tempered steel.
3. Overhead stops shall be of non-handed design.

2.13 WEATHERSTRIPPING, GASKETING AND SEALS

A. Manufacturer, or Equal:

1. Subject to the requirements indicated, provide products from the Manufacturer listed below, or equal.
 - a. McKinney.
 - b. Pemko.

B. Description:

1. Provide continuous weatherseal on exterior doors.
2. Provide continuous light or sound seals on interior doors where indicated.
3. Provide UL rated fire and smoke seals on all fire rated doors. Provide intumescent seals as required to meet UL 10C and the Code. Provide only those units where resilient or flexible seal strip is easily replaceable and readily available from stocks maintained by Manufacturer.

2.14 THRESHOLDS

A. Manufacturer, or Equal:

1. Subject to the requirements indicated, provide products from the Manufacturer listed below, or equal.
 - a. McKinney.
 - b. Pemko.

B. Description:

1. Provide threshold at each exterior door, and at other locations where indicated. Provided in size and configuration indicated, fabricated to accommodate door hardware and to fit door frames.
2. Thresholds shall be aluminum unless otherwise noted.
3. Threshold units shall comply with ADAAG and ANSI A 117.1.
4. At Fire Rated doors, provide UL rated thresholds.
5. Where adjacent floor material differs, provide threshold as appropriate.
6. Provide marble threshold at toilet rooms.

2.15 SILENCERS

A. Manufacturer, or Equal:

1. Subject to the requirements indicated, provide products from the Manufacturer listed below, or equal:
 - a. McKinney.
 - b. Pemko.

B. Description: Interior door frames shall be provided with rubber silencers, 3 for each single door and 2 for each pair of doors.

2.16 FASTENERS

- ### A. Provide necessary screws, bolts, and other fasteners of suitable size and type to secure the hardware into position. The fasteners shall match the hardware in material and finish.

- B. The hardware provided, such as expansion bolts, sex bolts, toggle bolts and other approved anchorages shall be coordinated with the job and to each setting condition.
- C. Phillips head screws shall be used at exposed conditions. Machine screws shall be used at metal doors and frames.
- D. Required screws shall be supplied as necessary for securing door hardware in the appropriate manner. Thru-bolts shall be supplied for exit devices and door closers where required by the Code and where the appropriate blocking or reinforcing is not present in the door to preclude their use.

2.17 FINISHES

- A. Door hardware shall be 630/US 32D (stainless steel satin finish) unless otherwise indicated.
- B. The designations used in schedules and elsewhere to indicate hardware finishes are those listed in ANSI A 156.18 including coordination with traditional U.S. finishes shown by certain Manufacturers for their products.
- C. Provide quality of finish, including thickness of plating or coating (if any), composition, hardness, and other qualities complying with Manufacturer's standards, but in no case less than specified by referenced standards for the applicable units of hardware.

PART 3 -- EXECUTION

3.01 DELIVERY, STORAGE, AND HANDLING

- A. Deliver materials to Site in Manufacturer's original, unopened packages, containers, or bundles with labels intact, which clearly identify contents.
 - 1. Locks, exit devices, door closers, overhead door holders, hinges, kickplates, pulls and push plates, thresholds, and other similar items shall be individually packed in separate, suitable, original, containers as furnished by the hardware Manufacturers. Each container shall be clearly marked with item numbers, article numbers, and names corresponding to those listed in the hardware schedule.
 - a. Small miscellaneous items that would not require specific location identifications, such as wall mounted stops and silencers may be quantity packed if properly labeled with item numbers and other identification.
 - 2. The Contractor shall check the hardware upon delivery with the aid of a representative of the hardware supplier's firm.
- B. Store materials carefully in accordance with the Manufacturer's written instructions, in an area that is protected from deleterious elements, and in a manner that will prevent damage to the products.
- C. Handle materials in strict accordance with Manufacturer's written instructions.

3.02 PROJECT CONDITIONS

- A. Comply with Manufacturer's written instructions for environmental conditions before, during, and after installation.

1. The Contractor shall make certain that the building is secured and free from weather elements prior to installing interior door hardware.
- B. Protect surrounding Work from damage that may result from operations under this Section.

3.03 INSPECTION

- A. The Contractor shall be totally responsible for the proper performance and completion of the Work under this Section.
- B. Systems and components shall be inspected before installation.
 1. Damaged or defective items shall be rejected and marked as such and shall be removed from the Site.
 2. Exposed surfaces that exhibit pitting, seam marks, roller marks, stains, discoloration, or other surface imperfections on the finished units shall be rejected.
- C. The Contractor shall verify dimensions, tolerances, and method of attachment with adjacent Work.
 1. Examine substrates, areas, and conditions where door hardware will be installed for compliance with the requirements for installation, taking into account tolerances, and other conditions affecting performance of installed door hardware.
 - a. Provide inserts, backing, blocking, anchoring devices, and reinforcements that must be built into other Work for the installation of door hardware. Coordinate delivery with other Work to avoid delay.
 2. Notify the Engineer in writing of conditions detrimental to the proper and timely completion of the Work. Do not proceed with the Work until unsatisfactory conditions have been corrected in an acceptable manner.
 3. Commencement of the installation by the Contractor shall indicate Contractor's acceptance of the substrate, areas, and conditions.

3.04 PREPARATION

- A. Sequence installation properly with the installation and protection of other Work, so that neither will be damaged by the installation of the other.

3.05 INSTALLATION

- A. Installation shall comply with the requirements of the Contract Documents, with applicable references, with the requirements of the Code, ADAAG, ANSI A 117.1 and with Manufacturer's written instructions. Where a conflict occurs among these requirements, the more stringent shall apply, as directed by the Engineer.
 1. Mount hardware units at heights indicated in the following applicable publications, except as specifically indicated or required to comply with the governing regulations.
 - a. The Contractor shall comply with DHI recommended locations for hardware as applicable for specified doors.

- B. The Contractor shall provide corrosion resistant fasteners, anchors, and shims required for a complete installation, and shall be secure, plumb, and true to line, allowing for required movement, including expansion and contraction.
- C. The Contractor shall provide separation of dissimilar materials to ensure no galvanic action occurs.
- D. Where cutting and fitting is required to install hardware onto or into surfaces that are later to be painted or finished in another way, coordinate removal, storage, and reinstallation or application of surface protection with finishing Work specified in the Division 9 Sections. Do not install surface-mounted items until finishes have been completed on the substrates involved.

3.06 CLEANING, FINISHING, AND PROTECTION

- A. Adhesive papers used for masking which become firmly bonded when exposed to heat and/or light shall not be used.
 - 1. Remove masking film and temporary labels as soon as possible after installation. Films and labels left in place after installation shall be the responsibility of the Contractor.
 - 2. Residue shall not be left on any surfaces.
- B. Upon completion of the installation, door hardware and appurtenances shall be cleaned of dirt and other foreign matter to the satisfaction of the Engineer.
 - 1. Cleaning shall be performed again immediately prior to acceptance of the Work, when directed by the Engineer.
 - 2. Cleaning shall be performed in accordance with the Manufacturer's written instructions.
- C. Adjusting and cleaning shall consist of ensuring smooth operation, lubricating and testing the door hardware.
 - 1. Door hardware shall operate smoothly, quietly, and without squeaking and binding.
 - a. The Contractor shall adjust and check each operating item of hardware and each door to ensure proper operation or function of every unit. Replace units that cannot be adjusted to operate freely and smoothly or as intended for the application made.
 - b. Latches and bolts shall be installed to automatically engage in keepers, whether activated by closers or by manual push. In no case should additional manual pressure be required to engage latch or bolt in keepers.
 - c. Closers and hinges shall be carefully adjusted to operate the doors noiselessly and evenly, and hinges shall be installed so as not to bind. Closers, closer arms, and hold-open arms shall be attached with sex bolts.
 - d. Adjust door control devices to compensate for final operation of heating and ventilating equipment.

- D. Door hardware shall be protected from damage from subsequent construction operations.
- E. The Contractor shall make adjustments required and retest until accepted.
- F. The Contractor shall remove scratches and blemishes to the satisfaction of the Engineer.
- G. Damaged or defective items shall be removed and replaced at the direction of the Engineer.
- H. When door hardware Work is completed, remove unused materials, containers, and equipment, and clean the Site of door hardware debris.
- I. The hardware Supplier shall do a final inspection prior to Substantial Completion to ensure that all hardware has been correctly installed and is in proper working order and shall provide a written report of this inspection to the Engineer the file.

3.07 HARDWARE SCHEDULE

A. The following schedule is furnished for whatever assistance it may afford the Contractor. The Contractor shall not consider it as entirely inclusive. Should any particular door or item be omitted in any scheduled hardware group, the Contractor shall provide door or item with hardware same as required for similar purposes as accepted by the Engineer, and at no additional cost to the Owner. Quantities listed are for each pair of doors, or for each single door.

B. Abbreviations:

- 1. BO – By Others.
- 2. KX – Knox Company.
- 3. MC – McKinney.
- 4. RX – Rixson.
- 5. SA – Sargent.
- 6. PMD – painted to match door.
- 7. W/SS – with security studs.

C. Hardware Schedule:

- 1. IS – Single Interior Doors (Electrical Room):

Quantity	Device	Description
Per Spec.	Hinges	
1	Exit Device (ANSI 08)	8313 ET with exterior trim
1	Closer	
Per Spec	Continuous Smoke Seals	Pemko S88
1	Threshold with seal	

DOOR HARDWARE

1	Threshold (where indicated)	Pemko 151 A Mill Aluminum
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2. TR – Interior Single Doors (Toilet Rooms):

Quantity	Device	Description
Per Spec.	Hinges	
1	Lockset (F22)	
1	Closer	
Per Spec.	Continuous Sounds Seals	
2	Kickplate	
1	Threshold	Marble, See Details

3. ES – Single Exterior Doors:

Quantity	Device	Description
Per Spec.	Hinges	
1	Exit Device (ANSI 08)	8313 ET with exterior trim
1	Closer	
1	Kickplate	
1	Threshold	Pemko 2005AV Mill Aluminum
1	Weatherstrip/Gasketing	Pemko S88D at Head and Jambs
1	Door Top Drip	Pemko 346 at Door Head
1	Door Bottom	Pemko 321DN Anodized Aluminum

4. ED – Double Exterior Doors:

Quantity	Device	Description
Per Spec.	Hinges	
1	Exit Device (ANSI 08)	8613 ET
1	Exit Device (ANSI 02)	8610
2	Closer	180 Degrees with Hold Open
2	Kick Plates	
1	Threshold	Pemko 2005AV Mill Aluminum
1	Weatherstrip/Gasketing	Pemko S88D at Head and Jambs
1	Door Top Drip	Pemko 346 at Door Head
2	Door Bottom	Pemko 321DN Anodized Aluminum

END OF SECTION

SECTION 08 91 00 – LOUVERS

PART 1 -- GENERAL

1.01 SUMMARY

A. Section Includes:

1. The Contractor shall provide louvers and appurtenant Work, complete, in place, and operational in accordance with the Contract Documents.
2. The Contractor shall furnish professional design and engineering services as required for louvers.
 - a. Professional design and engineering services may be provided by the Manufacturer or by an independent licensed civil engineer retained by the Contractor, either of which shall comply with the requirements indicated.
3. The Contractor shall coordinate color samples with other Sections through the submittal process.
4. The Contractor shall coordinate the requirements herein with the building heating, ventilating, and cooling system; see Division 15 Sections of these Specifications.
5. The Contractor shall coordinate wiring requirements and current characteristics of motor operators with the building electrical system; see Division 16 Sections of these Specifications.

1.02 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

A. Reference Specifications

01 33 00	Submittal Procedures
01 33 17	Structural Design, Support and Anchorage

- B. Where reference is made to any of the below, the revision in effect at the time of bid opening shall apply.

C. Reference Standards

Air Movement and Control Association (AMCA)	
Standard 500	Test Methods for Louvers, Dampers and Shutters
Standard 511	Certified Ratings Program for Air Control Devices
American Architectural Manufacturer's Association (AAMA)	
AAMA 2605	Voluntary Specification, Performance Requirements, and Testing Procedures for Superior Performing Organic Coatings on Aluminum Extrusions and Panels
ASTM International (ASTM)	
AAMA 2605	Voluntary Specification, Performance Requirements, and Testing Procedures for Superior Performing Organic Coatings on Aluminum Extrusions and Panels
ASTM B 211	Aluminum and Aluminum-Alloy Bar, Rod, and Wire

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ASTM B 209	Aluminum and Aluminum-Alloy Sheet and Plate
ASTM D 822	Standard Practice for Filtered Open Flame Carbon Arc Exposures of Paint and Related Coatings
ASTM D 2244	Standard Practice for Calculation of Tolerances and color Differences from Instrumentally Measured Color Coordinates
Building Code	
	Refer to the Drawings to determine which Building Code applies. The applicable Building Code, defined by the Drawings, is referenced herein as "the Code"
Sheet Metal and Air Conditioning Contractor's National Association (SMACNA)	
	Architectural Sheet Metal Manual (ASMM)

1.03 SUBMITTALS

A. Furnish submittals in accordance with Section 01 33 00 – Submittal Procedures

1.04 ACTION SUBMITTALS

A. Product Data:

1. Manufacturer's specifications, technical data, installation methods, and maintenance instructions, and the following:
 - a. Performance data in accordance with AMCA Standards 500 and 511.
 - b. AMCA licensed data demonstrating that each louver meets the criteria herein.
 - c. Manufacturer's full-range color charts, indicating custom color availability at no additional cost to the Owner, for color selection by the Owner.
 - d. Certificates:
2. Certification by the louver Manufacturer, that the louvers provided are suitable for, and compatible with, the required installation.
3. Certification of compliance with the requirements of paragraph 2.1.A.
4. Certification of Manufacturer qualifications demonstrating compliance with the qualifications requirements indicated. Include a list of 5 similar completed projects with addresses of the project location, date of project completion, Manufacturer's products, and contact information of the consultant firm of record, general contractor and owner.
5. Certification of installer qualifications demonstrating compliance with the qualifications requirements indicated. Include a list of 5 similar completed projects with addresses of the project location, date of project completion, and contact information of the consultant firm of record, general contractor and owner.
6. When requested by the Engineer, furnish other certifications as may be required to show compliance with the Contract Documents.

B. Shop Drawings and Calculations:

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1. Complete Shop Drawings showing location and detail of installation, and design calculations.
2. Shop Drawings and Calculations shall be prepared, approved, and stamped by a professional civil engineer licensed per local engineering licensing laws.
3. Shop Drawings shall be drawn to sufficient scale and shall include dimensions, show elevations and details of construction of each louver type, schedule of louvers, location and installation requirements for hardware, thickness of materials, joints, provisions for expansion and contraction, connections, accessories, and trim. Shop Drawings shall show installation conditions at openings with various wall thickness and materials.
 - a. Shop Drawings shall include material descriptions, finish, color, details of construction, installation, and accessories of each louver type.

C. Samples:

1. The Contractor shall submit 2 samples of each of the following. Unless otherwise indicated, samples shall be full size and shall show gauges, configuration, construction, finish and color proposed for the various components. Samples shall be clearly marked to show the Manufacturer's name, product identification, finish and color. New samples shall be resubmitted of each, as required, until approved by the Engineer. Upon approval, the samples shall become the standard for acceptance for the project with regard to color, finish, and quality of each item. Approval of samples shall not relieve the Contractor from compliance with the Contract Documents.
2. 3-in by 4-in color samples showing substrate, finish, and color.

1.05 CLOSEOUT SUBMITTAL

A. Warranty:

1. Submit a copy of the warranty.

1.06 QUALITY ASSURANCE

A. Single Source Responsibility:

1. Louvers shall be provided by a single Manufacturer, unless otherwise indicated.

B. Qualifications:

1. Manufacturers:

- a. Louver Manufacturer shall have a minimum of 20 years of louver manufacturing experience.
- b. Louver Manufacturer shall have a minimum of 5 similar successful projects over the most recent 10 years, employing similar products, materials, applications, and performance requirements.
- c. Manufacturers without these qualifications will not be accepted.

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2. Installers:

- a. Installer shall have a minimum of 5 years' experience in the successful completion of at least 5 projects of similar size and scope, employing similar products, materials, applications, and performance requirements.
- b. Installers without these qualifications will not be accepted.

3. Licensed Professionals:

- a. A professional civil engineer licensed per local engineering licensing laws shall design the louvers and connections to the structure.
- C. Fabrication practices, construction details, and installation procedures shall conform to the practices of SMACNA as recommended in the ASMM, as applicable and as required.
- D. Louvers shall bear AMCA Certified Ratings Seals for air performance and water penetration ratings

1.07 WARRANTY

A. Manufacturer Warranty:

1. Furnish Manufacturer's extended 20-year written warranty for the finish. Warranty shall include provisions for failures of the finish including, but not limited to, chalking, crazing, peeling, and fading.
 - a. Finish coating shall not chalk in excess of 8 numerical ratings when measured in accordance with ASTM D 4214
 - b. Finish color shall not change color or fade in excess of 5 NBS units as determined by ASTM D 2244 and ASTM D 822.
2. The Contractor shall furnish separate, but concurrently running, 5-year written warranty to cover labor.
3. Warranties shall be non-prorated for the entire warranty period.
4. The term of the warranties shall begin on the date of Substantial Completion.

PART 2 -- PRODUCTS

2.01 GENERAL

A. Structural Requirements:

1. Louvers, including related assemblies, components, and attachment details shall comply with the Code and shall be designed and installed for resistance to the structural design criteria indicated in the Contract Documents in accordance with the Code. Where a conflict occurs between the requirements of this Section and the Code, the more stringent shall apply.
 - a. Refer to Section 01 33 17 – Structural Design, Support and Anchorage for additional design criteria.

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2. The Contractor shall provide additional non-standard bracing, reinforcements, anchors, and heavier gauge materials in order to conform to the structural design criteria indicated and to other performance requirements indicated.
- B. Louvers shall be recommended by the Manufacturer for the installation indicated.
- C. Louvers shall be suitable for, and compatible with, the required installation.
- D. Design Requirements:
1. Louver system Manufacturer shall furnish the systems herein, including necessary custom modifications to meet the indicated requirements and to maintain the visual design requirements as approved by the Engineer.
 2. Stationary components of louvers shall be of all-welded design.
 3. Aluminum Sheet: ASTM B 209, Alloy 3003 and 5005 with temper as required for forming or as otherwise recommended by the metal producer to provide the required finish.
 4. Aluminum Extrusions: ASTM B 211, Alloy 6063-T5, 6063-T6, or 6061-T6, unless otherwise indicated.
 5. Supports, anchorage, and accessories shall be provided as required for complete assembly.
 6. Perimeter conditions shall allow for installation tolerances, expansion and contraction of adjacent materials, and sealant Manufacturer's recommended joint design.
 7. The Contractor shall not assume sealant and interior finishes contribute to framing member strength, stiffness, or lateral stability.
 8. Assemblies shall be free from vibration harmonics, rattles, wind whistles, and noise due to thermal movement, thermal movement transmitted to other building elements, and wind pressure. Assemblies shall be free from loosening, weakening, or fracturing of attachments by components.
 9. Attachment considerations are to take into account Site peculiarities and expansion and contraction movements so there is no possibility of loosening, weakening, or fracturing connection between units and building structure or between units themselves.
 10. System shall drain any water entering system to the exterior of system.
 11. Concealed fastening shall be provided.
 12. Uniform color and profile appearance shall be provided at components exposed to view.
- E. Expansion and Contraction Requirements: Louver systems shall accommodate expansion and contraction movement due to surface temperature differentials without causing buckling, stresses on adjacent Work, undue stress on structural elements, damaging loads on fasteners, reduction of performance, or other visual or technical detrimental effects.

LOUVERS

2.02 COMBINATION DRAINABLE LOUVERS

A. Manufacturer and Product, or Equal:

1. Subject to the requirements indicated, provide Manufacturer and product listed below, or equal.
 - a. Combination wall louvers shall be Ruskin Model ELC 6375DAX.

B. Description:

1. Combination drainable louvers shall be adjustable type with drain gutter in each blade and downspouts/drainage channels in jambs and mullions. Stationary blades and adjustable blades shall be contained within a single 6-in louver frame. Adjustable Section shall include low leakage blade and jamb seals. Components (heads, jambs, blades, and mullions) shall be factory assembled by the louver Manufacturer. Waterstop at sill shall be factory caulked water tight.
2. Heads, sills, jambs, mullions, and sills shall be one-piece structural aluminum members with integral caulking slot and retaining beads. Material thickness shall be 0.125-in. Mullions shall be sliding interlock with internal drains. Blades shall be one-piece aluminum extrusions with gutters designed to catch and direct water to jamb and mullion drains. Compression gaskets shall be provided between bottom of mullion or jamb and top of sill to insure leak tight connections.
 - a. Continuous, 0.125-in thick perimeter angles of same material as louvers shall be provided for attachment on inside to adjacent construction. At louvers over 6-feet (1.8 m) wide, center vertical aluminum angle support and approved aluminum blade braces shall be provided, each blade. Secure top and bottom and to each brace and blade.
3. Frame: 6-in deep, 6063-T5 extruded aluminum, with .125-in nominal wall thickness. Downspouts/drainage channels and caulking surfaces shall be provided.
4. Blades: Front stationary drainage blades, 6063-T5 extruded aluminum with .081-in nominal wall thickness, positioned at 37½ degree angle and spaced approximately 6 1/8-in on center. Rear adjustable airfoil blades, 6063-T5 extruded aluminum, 0.140-in nominal wall thickness.
5. Motor Operator: Electric type furnished with louver, 120 volts max.

C. Performance Requirements:

1. AMCA Performance:

- a. A 4 ft by 4 ft unit shall be licensed to bear the AMCA seal, and shall conform to the following:

Free Area	Minimum 7.48 sq. ft
Percent Free Area	Minimum 47 percent
Velocity at the Point of Beginning Water Penetration of 0.01 oz/sq. ft.	1169 FPM (.36 KPM)
Pressure Drop at the Point of Beginning Water Penetration	0.15-in water
Air volume	7,000 cfm

2.03 DRAINABLE STATIONARY LOUVERS

A. Manufacturer and Product, or Equal:

1. Subject to the requirements indicated, provide Manufacturer and product listed below, or equal.
 - a. Combination wall louvers shall be Ruskin Model ELF 6375DXH.

B. Description

1. Drainable stationary louvers shall have drain gutter in each blade and downspouts/drainage channels in jambs and mullions. Stationary blades shall be contained within a single 6 in louver frame. Components (heads, jambs, blades, and mullions) shall be factory assembled by the louver Manufacturer. Waterstop at sill shall be factory caulked water tight.
2. Heads, sills, jambs, mullions, and sills shall be one-piece structural aluminum members with integral caulking slot and retaining beads. Material thickness shall be 0.125 in. Mullions shall be sliding interlock with internal drains. Blades shall be one-piece aluminum extrusions with gutters designed to catch and direct water to jamb and mullion drains. Compression gaskets shall be provided between bottom of mullion or jamb and top of sill to insure leak tight connections.
 - a. Continuous, 0.125 in thick perimeter angles of same material as louvers shall be provided for attachment on inside to adjacent construction. At louvers over 6 ft wide, center vertical aluminum angle support and approved aluminum blade braces shall be provided, each blade. Secure top and bottom and to each brace and blade.
3. Frame: 6-in deep, 6063-T5 extruded aluminum, with .125-in nominal wall thickness. Downspouts/drainage channels and caulking surfaces shall be provided.
4. Blades: Stationary drainage blades, 6063-T5 extruded aluminum with .081-in nominal wall thickness, positioned at 37½ degree angle and spaced approximately 6 1/8 in on center.

C. Performance

1. AMCA Performance:

LOUVERS

- a. A 4 ft by 4 ft unit shall be licensed to bear the AMCA seal, and shall conform to the following:

Free Area	Minimum 9.08 sq. ft
Percent Free Area	Minimum 57 percent
Velocity at the Point of Beginning Water Penetration of 0.01 oz/sq. ft.	1023 FPM (312 MPM)

2.04 ACOUSTICAL LOUVERS

A. Manufacturer and Product, or Equal:

1. Subject to the requirements indicated, provide Manufacturer and product listed below, or equal.

- a. Louvers shall be Ruskin Model ACL 1245.

B. Description:

1. Louvers meeting the following specifications shall be furnished and installed where shown on the plans and/or as described in schedules. Louvers too large for complete factory assembly shall be built up by the installing Contractor from factory assembled Sections. Louver frames, mullions and Section joints shall be adequately supported from the building structure to withstand this wind loading.
2. Louvers shall be acoustical stationary Airfoil blade, fabricated from aluminum. Louver frame depth shall be 12 in. Acoustical material shall be fiberglass insulation. Blades and frames will be mechanically fastened together. Each louver shall be equipped with a framed, removable, rear-mounted screen of flattened expanded aluminum.
3. Comprehensive louver performance data including airflow resistance, water penetration, Sound Transmission Class (STC), Outdoor Indoor Transmission Class (OITC) and free area shall be submitted for approval. Louvers must be AMCA certified for airflow resistance and water penetration. Acoustical testing must be performed by an independent laboratory.

C. Performance:

1. AMCA Performance:

- a. A 4 ft by 4 ft unit shall be licensed to bear the AMCA seal, and shall conform to the following:

Free Area	Minimum 3.49 sq. ft.
Percent Free Area	Minimum 22 percent
Velocity at the Point of Beginning Water Penetration of 0.01 oz/sq. ft.	1025 FPM (312 MPM)

2.05 FRP STATIONARY BLADE LOUVERS

A. Manufacturer and Product, or Equal:

LOUVERS

1. Subject to the requirements indicated, provide Manufacturer and product listed below, or equal.
 - a. Fixed Type FRP louvers shall be Composite Fan Technology, FRP Louvers, or equal.

B. Description:

1. Louvers shall be constructed of isophthalic polyester fire-retardant resin, equivalent to Hetron 99P polyester resin with a Class 1 flamespread of 25 or less.
2. Ultraviolet inhibitors shall be incorporated into the resin.
3. Louver sections shall include fiberglass unidirectional filaments and a synthetic veil.
4. Provide a minimum of 40 percent glass by weight.
5. Coloring shall be achieved by the use of pigments impregnated through the entire profile.
6. Louver frames shall be 6-in deep, of the channel type, and provided with a minimum thickness of 1/4-in.
7. Louver blades shall be:
 - a. Of a "K" style design.
 - b. Provided with a minimum thickness of 1/8-in.
 - c. Provided with a 45 degree opening.
8. Hardware shall be fabricated from Type 306 stainless steel.
9. Provide the following accessories:
 - a. A 1/2-in mesh polyethylene screen mounted in a removable PVC frame.
 - b. Fiberglass mullion covers.

C. Performance:

Free Area	Minimum 9.08 sq. ft.
Percent Free Area	Minimum 57 percent
Velocity at the Point of Beginning Water Penetration of 0.01 oz/sq. ft.	1023 FPM (312 MPM)

2.06 ACCESSORIES

A. Sill Extensions/Flashing:

1. Except for FRP stationary blade louvers, sill extensions/flashing shall be one-piece, extruded 0.060, aluminum.

- a. Sill extensions/flashing for FRP stationary blade louvers shall be one-piece fiberglass reinforced plastic to match the FRP louver.
 2. Sill extension/flashing finish shall be the same as louver, custom color to match adjacent exterior wall, as approved by the Engineer.
- B. Insulated Blank-Off Panels:
1. Insulated blank-off panels shall be provided where required to seal-off louver area not connected to ductwork or to cover areas not required for free air. Insulated blank-off panels shall be provided by the louver Manufacturer and shall consist of 2-in glass fiberboard insulation encapsulated and sealed completely in 0.032-in aluminum skins, securely fastened to louvers and ductwork.
 2. Insulated blank-off panel finish shall be same as louvers, flat black in color, unless otherwise indicated.
- C. Screens:
1. Bird Screen: Each exterior louver shall be provided with $\frac{3}{4}$ -in by 0.051-in mesh aluminum wire bird screen secured within rewireable extruded aluminum frame as approved. Attach to interior face of louver, unless otherwise noted.
 2. Insect Screen: For exterior louvers not connected to ductwork, provide separate fiberglass insect screen, frame, and accessories mounted to interior face of bird screen.
 - a. Insect screen shall be installed such that it is removable to allow for frequent maintenance and cleaning.
 3. Screens shall be secured to louver frames with removable machine screws, spaced at each corner and at 12-in on center, minimum, between corners
 4. Screens and frames shall have same finish as louvers, color shall be black.
 5. Fasteners: Fasteners shall be structural-grade aluminum. Provide materials, types, gauges, and lengths to suit unit installation conditions. Phillips flat-head machine screws shall be used for exposed features, unless otherwise indicated.
 6. Anchor and inserts: Anchors and inserts shall be non-ferrous metal for exterior installations and elsewhere as required for corrosion resistance. Steel expansion bolt devices shall be used for drilled-in-place anchors. Concrete inserts shall be provided as required.

2.07 FINISH AND COLOR

- A. Finish system shall be 1.2-mil, PVF2 Kynar 500, formulated by a licensed formulator to contain 70 percent PVF resin and applied by a licensed applicator.
 1. The surface condition of this finish coat shall be 100 percent free of holidays, drip marks, scratches, roll marks, or abrasions that are visible from a distance of 5 ft in good light when in installed position. Surfaces shall be free of checking, crazing, peeling, or loss of adhesion.
 2. Finish shall meet or exceed AAMA 2605.

LOUVERS

3. Color shall be selected and approved by the Owner from Manufacturer's full color range including custom colors, and may be required to exactly match other building components, as determined by the Owner, at no additional cost to the Owner.
 - a. Tentative color selection: To be Selected.
 - b. The Owner reserves the option of changing this tentative color selection during the submittal process.

2.08 FABRICATION

- A. The Contractor shall field verify size, location, and placement of louvers, shall advise the Engineer in writing of any necessary adjustments, and shall make the necessary adjustments prior to fabrication. The Contractor shall coordinate field measurements and Shop Drawings with fabrication and shop assembly to minimize field adjustments.
 1. Louvers shall be assembled before shipment to the Site.
 2. Accurate relation of planes and angles shall be maintained, with hairline fit of contacting members.

PART 3 -- EXECUTION

3.01 DELIVERY, STORAGE, AND HANDLING

- A. Deliver materials to Site in Manufacturer's original, unopened packages, containers, or bundles with labels intact, which clearly identify contents.
- B. Store materials carefully in accordance with the Manufacturer's written instructions, in an area that is protected from deleterious elements, and in a manner that will prevent damage to the products.
- C. Handle materials in strict accordance with Manufacturer's written instructions.

3.02 PROJECT CONDITIONS

- A. Comply with Manufacturer's written instructions for environmental conditions before, during, and after installation.
- B. Protect surrounding Work from damage that may result from operations under this Section.

3.03 INSPECTION

- A. The Contractor shall be totally responsible for the proper performance and completion of the Work under this Section.
- B. Systems and components shall be inspected before installation.
 1. Damaged or defective items shall be rejected and marked as such and shall be removed from the Site.
 2. Exposed surfaces that exhibit pitting, seam marks, roller marks, stains, discoloration, or other surface imperfections on the finished units shall be rejected.

- C. The Contractor shall verify dimensions, tolerances, and method of attachment with adjacent Work.
 - 1. Examine substrates, areas, and conditions where louvers and appurtenances will be installed for compliance with the requirements for installation, taking into account tolerances, and other conditions affecting performance of installed louvers.
 - a. Provide inserts, backing, blocking, anchoring devices, and reinforcements that must be built into other Work for the installation of louvers. Coordinate delivery with other Work to avoid delay.
 - 2. Notify the Engineer in writing of conditions detrimental to the proper and timely completion of the Work. Do not proceed with the Work until unsatisfactory conditions have been corrected in an acceptable manner.
 - 3. Commencement of the installation by the Contractor shall indicate Contractor's acceptance of the substrate, areas, and conditions.

3.04 PREPARATION

- A. Sequence installation properly with the installation and protection of other Work, so that neither will be damaged by the installation of the other.

3.05 INSTALLATION

- A. Installation shall comply with the requirements of the Contract Documents, with applicable references, with the requirements of the Code, and with Manufacturer's written instructions. Where a conflict occurs among these requirements, the more stringent shall apply, as directed by the Engineer.
- B. The Contractor shall provide corrosion resistant fasteners, anchors, and shims required for a complete installation, and shall be secure, plumb, level, straight, and true to line, allowing for required movement, including expansion and contraction.
- C. The Contractor shall provide separation of dissimilar materials to ensure no galvanic action occurs.
- D. The Contractor shall block and reinforce walls as required to support the louvers and appurtenances.
- E. Horizontal lines shall be level, and vertical lines shall be plumb.
- F. Sill extensions shall be provided at exterior louver installations.

3.06 CLEANING, FINISHING, AND PROTECTION

- A. Adhesive papers used for masking which become firmly bonded when exposed to heat and/or light shall not be used.
 - 1. Remove masking film and temporary labels as soon as possible after installation. Films and labels left in place after installation shall be the responsibility of the Contractor.
 - 2. Residue shall not be left on any surfaces.

LOUVERS

- B. Upon completion of the installation, louvers and appurtenances shall be cleaned of dirt and other foreign matter to the satisfaction of the Engineer.
 - 1. Cleaning shall be performed again immediately prior to acceptance of the Work, when directed by the Engineer.
 - 2. Cleaning shall be performed in accordance with the Manufacturer's written instructions.
- C. Louvers shall be protected from damage from subsequent construction operations.
- D. The Contractor shall make adjustments required and retest until accepted.
- E. The Contractor shall remove scratches and blemishes to the satisfaction of the Engineer.
- F. Damaged or defective items shall be removed and replaced at the direction of the Engineer.
- G. When louver Work is completed, remove unused materials, containers, and equipment, and clean the Site of louver debris.

END OF SECTION

SECTION 09 30 13 – CERAMIC TILE

PART 1 -- GENERAL

1.1 THE SUMMARY

- A. The CONTRACTOR shall provide ceramic tile and appurtenant WORK, complete and in place, in accordance with the Contract Documents.
- B. The CONTRACTOR shall coordinate color samples with other Sections through the submittal process.

1.2 REFERENCES

- A. Where reference is made to any of the below, the revision in effect at the time of bid opening shall apply.

- B. Americans with Disabilities Act (ADA):

ADAAG Americans with Disabilities Accessibility Guidelines

- C. American Society of Testing and Materials (ASTM):

ASTM C 241 Standard Test Method for Determining Abrasion Resistance of Stone Subjected to Foot Traffic

ASTM C 503 Standard Specification for Marble Dimension Stone

ASTM C 1028 Standard Test Method for Determining the Static Coefficient of Friction of Ceramic Tile and Other Like Surfaces by the Horizontal Dynamometer Pull-Meter Method

ASTM F 2170 Standard Test Method for Determining Relative Humidity in Concrete Slabs using In Situ Probes

- D. American National Standards Institute (ANSI):

ANSI A 108.5 Installation of Ceramic Tile with Dry-Set Portland Cement Mortar or Latex Portland Cement Mortar

ANSI A 108.10 Installation of Grout in Tile WORK

ANSI A 118.4 Latex-Portland Cement Mortar

ANSI A 118.7 Specification for Polymer Modified Tile Grouts for Tile Installation

ANSI A 137.1 Standard Specification for Ceramic Tile

- E. Building CODE: Refer to the Drawings to determine which building code applies within a given jurisdiction. The applicable building code, defined by the Drawings, is referred to herein as “the CODE.”

- F. Marble Institute of America (MIA): Dimension Stone Design Manual IV.

- G. South Coast Air Quality Management District (SCAQMD):

H. Tile Council of America (TCA): Handbook for Ceramic Tile Installation (CIT).

1.3 CONTRACTOR SUBMITTALS

A. Furnish submittals in accordance with Section 01 33 00 – Contractor Submittals.

B. Literature: Manufacturer's specifications, technical data, installation methods, and maintenance instructions, and the following:

1. Tile Manufacturer's standard color charts for color selection by the OWNER.
2. Grout Manufacturer's standard color charts for color selection by the OWNER.

C. Warranty: Submit a copy of the warranty.

D. Certifications:

1. Certification by the tile Manufacturer that the tile materials provided are suitable for, and compatible with, the required installation.
2. Master Grade Certificate for each shipment, stating the grade, type, and composition of tile, identification marks for tile packages, and the name and location of the project.
 - a. The certificates shall be signed by the tile Manufacturer and installer and shall be issued when tile is shipped, before beginning any tile WORK.
 - b. The certificate shall show that the tile, mortar, and grout complies with the requirements of the Tile Council of America Inc. (TCA).
 - c. Adequate information shall be included on the certificate for identifying corresponding shipping packages.
 - d. Include certifications and other data as may be required to show compliance with these specifications.
3. Certification of recycled content as required for select materials herein.
4. Independent certification that the products comply with the VOC limits and VOC performance criteria indicated.
5. Certification of installer qualifications demonstrating compliance with the qualifications requirements indicated. Include a list of 5 similar completed projects with addresses of the project location, date of project completion, and contact information of the consultant firm of record, general contractor and owner.
6. Certification that the required substrate tests have been performed, and that the substrates are suitable for the installation.

E. Shop Drawings: Complete shop drawings showing location and detail of installation.

1. Include details, tile layout, colors and pattern distribution.

2. Show ceramic tile control joints and demonstrate coordination with substrate control joint locations.
- F. Samples: The CONTRACTOR shall submit 2 samples of each of the following. Unless otherwise indicated, samples shall be full size and shall show configuration, construction, finish and color proposed for the various components. Samples shall be clearly marked to show the Manufacturer's name, product identification, finish and color. New samples shall be resubmitted of each, as required, until approved by the ENGINEER. Upon approval, the samples shall become the standard for acceptance for the project with regard to color, finish, and quality of each item. Approval of samples shall not relieve the CONTRACTOR from compliance with the Contract Documents.
1. Panel sample of each tile type, showing specified finish and color, mounted on not less than 16-inch (41 cm) square plywood or hardboard backing and grouted as required.
 2. Sample palettes of each grout type, showing full color range. Each individual grout sample shall be 6-inches (15 cm) long by 3/8-inch (9.65 mm) wide.
 3. Representative samples of specified marble thresholds, 6-inches (15 cm) long by width indicated.

1.4 QUALITY ASSURANCE

- A. Product Certificates: Tile shall be delivered with quality certificates of the Tile Council of America (TCA) and shall meet the CODE requirements.
- B. Single Source Responsibility:
1. Ceramic tile shall be provided by a single Manufacturer. Each color, grade, finish, type, composition, and variety of tile shall be obtained from a single production run.
 2. Ingredients for each mortar, adhesive, and grout component shall be obtained from a single Manufacturer and each aggregate shall be from one source or producer.
 3. Mortar and grout shall be provided from a single Manufacturer, each.
 4. Shower receptors shall be provided from a single Manufacturer.
- C. Tile WORK shall be not less than standards and references established within the CIT by the TCA.
- D. Tile installation shall conform to ANSI A 108.5 as indicated for tile and A 108.10 for grouting.

1.5 SPECIAL WARRANTY PROVISIONS

- A. Ceramic Tile: Furnish Manufacturer's 2 year written warranty to cover defects in materials, products, and manufacturing workmanship. The term of the warranty shall begin on the date of Substantial Completion.

PART 2 -- PRODUCTS

2.1 GENERAL

- A. Ceramic tile shall comply with ANSI A 137.1.
- B. Ceramic tile adhesives, sealants, and sealant primers shall be low VOC per SCAQMD Rule No. 1168.

2.2 CERAMIC TILE (WALL TILE)

- A. Manufacturer and Product, or Equal:
 - 1. Subject to the requirements herein, provide products from the Manufacturer listed below, or equal.
 - a. **DalTile Corporation, American Olean Bright Wall Tile**, unless otherwise indicated.
- B. Description:
 - 1. Wall tile shall be 4 1/4-inches (108 mm) square, 5/16-inch (7.9 mm) thick, cushion edge, bright glaze (glossy).
 - 2. Provide with required shapes such as cove base, bullnose, angle, and other trim items matching tile as required.
 - 3. Provide in Color Group 1.
 - 4. Installation shall be on concrete masonry units.

2.3 CERAMIC TILE (FLOOR TILE)

- A. Manufacturer and Product, or Equal:
 - 1. Subject to the requirements herein, provide products from the Manufacturer listed below, or equal.
 - a. **DalTile Corporation, American Olean Unglazed Ceramic Mosaic floor tile**.
- B. Description:
 - 1. Toilet, Shower, and Locker Rooms: Floor tile shall be mosaic, 2-inches square (51 mm), 1/4-inch thick (6.35 mm), cushion edge, unglazed vitreous tile.
 - 2. Provide cove base as indicated for wall tile above.
 - 3. Provide in Color Group 2.
 - 4. Floor tile shall have the following characteristics:

Performance Characteristics	Mosaic floor tile
ASTM C 1028 Coefficient of Friction (COF)	≥ 0.60 wet; ≥ 0.70 dry
Moisture Absorption	< 3.0 percent
Breaking Strength	>250lb

2.4 TILE COLOR GROUPS

- A. Color of tile shall be as selected and approved by the OWNER from Manufacturer's full color range.
1. Tentative color selection: The OWNER reserves the option of changing this tentative color selection during the submittal process.

	Color Group 1	Color Group 2
Color A	Designer White 61	To Be Selected
Color B	Storm Gray 40	To Be Selected

2. Final colors, pattern, and appearance shall be selected and approved by the OWNER prior to installation.

2.5 MORTAR

- A. Dry-set mortar (walls) shall conform to ANSI A 118.1 and shall have the TCA hallmark.
- B. Latex-Portland cement mortar (floors) shall conform to ANSI A 118.4 and shall have the TCA hallmark.

2.6 GROUT

- A. Polymer modified grout (walls and floor) shall conform to shall conform to ANSI A 118.7.
- B. Color of grout shall be as selected and approved by the OWNER

2.7 GROUT SEALER

- A. Grout sealer shall be low VOC per SCAQMD Rule No. 1168, clear penetrating type, as recommended by grout Manufacturer.

2.8 MIX WATER

- A. Water shall be fresh, clean, potable, and shall be free from organic matter, acids, and alkalis.

2.9 MARBLE THRESHOLDS

- A. Marble thresholds shall comply with ASTM C 503, and shall be classified Group A per definitions for soundness per MIA "Dimension Stone Design Manual IV."
- B. Coefficients of Friction (COF) for marble thresholds shall be as indicated above for floor tile. Marble abrasion shall be not less than 12.0 when tested in accordance with ASTM C 241. Marble thresholds shall comply with 36 CFR 1191 for coefficient of friction for interior floors.
- C. Marble thresholds shall be honed, solid marble, white color, in size, and configuration as indicated.

PART 3 -- EXECUTION

3.1 DELIVERY, STORAGE, AND HANDLING

- A. Deliver materials to Site in Manufacturer's original, unopened packages, containers, or bundles with labels intact, which clearly identify contents.
- B. Store materials carefully in accordance with the Manufacturer's written instructions, in an area that is protected from deleterious elements, and in a manner that will prevent damage to the products.
- C. Handle materials in strict accordance with Manufacturer's written instructions.

3.2 INSPECTION

- A. The CONTRACTOR shall be totally responsible for the proper performance and completion of the WORK under this Section.

B. Systems and components shall be inspected before installation.

1. Damaged or defective items shall be rejected and marked as such and shall be removed from the Site.
2. Exposed surfaces that exhibit pitting, stains, discoloration, or other surface imperfections on the finished units shall be rejected.

C. The CONTRACTOR shall verify dimensions, tolerances, and method of attachment with adjacent WORK.

1. Examine substrates, areas, and conditions where tile will be installed for compliance with requirements for installation, taking into account tolerances, and other conditions affecting performance of installed tile.
 - a. Substrates for setting tile shall be firm, sound, dimensionally stable, dry, clean, free from oil, waxy films, and curing compounds; and shall be within flatness tolerances required by referenced standards.
 - b. Perform substrate humidity test in accordance with ASTM F 2170. Comply with tile Manufacturer's written instructions to achieve acceptable relative humidity levels in the concrete slab prior to applying flooring materials. In no case should the humidity levels in the slab be greater than 75 percent, prior to applying materials.
 - c. Installation of grounds, anchors, recessed frames, electrical and mechanical units of WORK, and similar items located in or behind tile shall be completed before installing tile.
 - d. Joints and cracks in tile substrates shall be coordinated with tile movement joint locations.
 - e. For wall tile, maximum variation in tile substrate shall be 1/8-inch (32 mm) from the required plane in 8-feet (2.4 m) of wall.
2. Notify the ENGINEER in writing of conditions detrimental to the proper and timely completion of the WORK. Do not proceed with the WORK until unsatisfactory conditions have been corrected in an acceptable manner.
3. Commencement of the installation by the CONTRACTOR shall indicate CONTRACTOR's acceptance of the substrate, areas, and conditions.

3.3 PROJECT CONDITIONS

- A. Comply with Manufacturer's written instructions, TCA, and ANSI standards for environmental conditions before, during, and after application.
1. Do not install tile until areas have been fully enclosed and environmental conditions have reached the levels indicated during occupancy.
 2. Maintain ambient temperature and humidity conditions during and after installation of tile at levels indicated during occupancy.
 3. Allow tile to reach room temperature or minimum temperature recommended by Manufacturer before beginning installation.

4. Protect adhesives from freezing. Follow Manufacturer's recommendations for minimum temperatures to which adhesives are exposed.
- B. Protect surrounding WORK from damage that may result from operations under this Section.

3.4 SURFACE PREPARATION

- A. Surface preparation shall be in compliance with the referenced standards, and with the Manufacturer's written instructions.
- B. Coatings, including curing compounds, and other substances that contain soap, wax, oil, or silicone, that are incompatible with tile-setting materials shall be removed by using a terrazzo or concrete grinder, a drum sander, or a polishing machine equipped with a heavy-duty wire brush.
- C. Where concrete substrates are indicated, provide latex-Portland cement mortars that comply with flatness tolerances in ANSI A 108.
- D. Protrusions, bumps, ridges, and loose substrate surface materials shall be removed by sanding or grinding.
- E. Trowelable leveling and patching compounds shall be used per tile Manufacturer's written instructions to fill cracks, holes, and depressions.
- F. Immediately before application of tile materials, scrape surfaces to be covered free from foreign materials and brush clean.
- G. Substrate shall be swept to remove all loose materials prior to beginning ceramic tile installation.

3.5 PREPARATION

- A. Sequence installation properly with the installation and protection of other WORK, so that neither will be damaged by the installation of the other.
- B. Blending Tile: For tile exhibiting color variations within the ranges selected during sample submittals, The CONTRACTOR shall verify that tile has been blended in the factory and packaged so tile units taken from one package show the same range in colors as those taken from other packages and match approved samples. If not factory blended, tile shall either be returned to Manufacturer or blended at Site to the satisfaction of the ENGINEER before installing.
- C. Jointing Pattern: Tile shall be laid in grid pattern, unless otherwise indicated. Joints shall be aligned when adjoining tiles on floor, base, walls, and trim are the same size. Tile WORK shall be laid out with tile fields centered in both directions in each space or on each wall area. Align joints to give straight uniform grout lines, plumb, and level. Align floor joints to give straight uniform grout lines parallel with walls. Adjustments shall be made to minimize tile cutting. Uniform joint widths shall be provided, unless otherwise indicated. Make joints between tile sheets same width as joints within sheets, so that extent of each sheet is not apparent in finished WORK.
- D. Movement Joints:

1. Expansion joints and other sealant-filled joints, including control, contraction, and isolation joints, shall be located where indicated during installation of setting materials, mortar beds, and tile. Joints shall not be saw-cut after installing tiles.
 - a. Joints shall be located in tile surfaces directly above joints in concrete substrates.
 - b. Joints shall be prepared and sealants shall be applied to comply with Section 07 92 13 - Sealants and Caulking.

E. Mortar and Grout Mixing:

1. Mortars and grouts shall be mixed to comply with referenced standards and to comply with mortar and grout Manufacturer's written instructions.
2. Materials, water, and additives shall be added in accurate proportions.
3. The CONTRACTOR shall use mixing equipment, mixer speeds, mixing containers, mixing time, and procedures to produce mortars and grouts of uniform quality with optimum performance characteristics.

F. Cut edges clean before installing tile. Fit tile carefully against trim, accessories, ground pipes, electric boxes, and other built-in fixtures so that escutcheons, plates, and collars will completely overlap cut edges.

3.6 INSTALLATION – WALL TILE

- A. Installation shall comply with the requirements of the Contract Documents, with the requirements of the CODE, with ADAAG, with applicable references, and with Manufacturer's written instructions. Where a conflict occurs among these requirements, the more stringent shall apply, as determined by the ENGINEER.
- B. Install wall tile in accordance with ANSI A 108.5 and TCA Method W 244.
- C. Install grout per ANSI A 108.10.
- D. Set tile in minimum notched bed of 3/32-inch (2.4 mm) thickness trowel
- E. Should some "flash-patching" be necessary to alleviate minor unit-to-unit variance in masonry back-up, the addition of fine-screened sand in recommended proportion will be allowed. No other modification of the Manufacturer's formulation will be permitted.
- F. Walls Tile Joint Widths: 1/16-inch (1.6 mm), unless otherwise indicated.

3.7 INSTALLATION – FLOOR TILE AND MARBLE THRESHOLDS

- A. Installation shall comply with the requirements of the Contract Documents, with the requirements of the CODE, with ADAAG, with applicable references, and with Manufacturer's written instructions. Where a conflict occurs among these requirements, the more stringent shall apply, as directed by the ENGINEER.
- B. Install floor tile per ANSI A 108.5 and TCA Method F113.
- C. Install grout per ANSI A 108.10.

- D. Floor Tile Joint Widths: Mosaic Floor Tile: 1/8-inch (3.2 mm), unless otherwise indicated.
- E. Thresholds shall be installed at locations indicated; thresholds shall be set in same type of setting bed as abutting field tile, unless otherwise indicated.
 - 1. Thresholds shall be set in latex-Portland cement mortar for locations where mortar bed would otherwise be exposed above adjacent non-tile floor finish.

3.8 GROUTING

- A. Grout joints full to the bottom of the rounded edge of the bevel or flush at square edge tile. Grout shall be forced into joints according to Manufacturer's instructions. Joints shall be sponged and tooled. Fog grouting as required for proper curing.
- B. Provide open joints for sealant where required.

3.9 INSTALLATION – SHOWER RECEPTOR

- A. Installation shall comply with the requirements of the Contract Documents, with the requirements of the CODE, with applicable references, and with Manufacturer's written instructions. Additionally, shower receptors installed in handicapped accessible showers, where indicated, shall comply with ADAAG. Where a conflict occurs among these requirements, the more stringent shall apply, as determined by the ENGINEER.

3.10 CLEANING, FINISHING, AND PROTECTION

- A. Cleaning:
 - 1. Adhesive papers used for masking which become firmly bonded when exposed to heat and/or light shall not be used.
 - a. Remove masking film and temporary labels as soon as possible after installation. Film and labels left in place after installation shall be the responsibility of the CONTRACTOR.
 - b. Latex-Portland cement grout residue shall be removed from tile as soon as possible.
 - c. Residue shall not be left on any surfaces
 - 2. Upon completion of the installation, ceramic tile and appurtenances shall be cleaned of all dirt, adhesives, and other foreign matter to the satisfaction of the ENGINEER.
 - a. Cleaning shall be performed again immediately prior to acceptance of the WORK, when directed by the ENGINEER.
 - b. Cleaning shall be performed in accordance with the Manufacturer's written instructions.
 - 3. Before final inspection, protective coverings shall be removed and neutral cleaner shall be rinsed from tile surfaces.
- B. Finishing: Finished installation shall be left clean and free of cracked, chipped, broken, nonbonded, and otherwise defective tile WORK.

C. Protection:

1. Ceramic tile shall be protected from damage from subsequent construction operations.
 - a. Protect the WORK at all times and arrange for the closing off of traffic and other WORK when this is necessary to avoid damage to finished surfaces.
 - b. When recommended by tile Manufacturer, a protective coat of neutral protective cleaner shall be applied to completed tile walls and floors. Installed tile shall be protected with kraft paper or other heavy covering during construction period to prevent staining, damage, and wear.
 - c. Foot and wheel traffic shall be prohibited from tiled floors for at least 7 days after grouting is completed, and be allowed thereafter only after approval of Installer.
- D. The CONTRACTOR shall remove scratches and blemishes to the satisfaction of the ENGINEER.
- E. Damaged or defective items shall be removed and replaced at the direction of the ENGINEER.
- F. When ceramic tile WORK is completed, remove unused materials, containers, and equipment, and clean the Site of ceramic tile debris.

END OF SECTION

SECTION 09 96 00 – HIGH-PERFORMANCE COATINGS

PART 1 -- GENERAL

1.01 SUMMARY

- A. The Contractor shall provide protective coatings, complete and in place, in accordance with the Contract Documents.
- B. Definitions
 - 1. The term "paint," "coatings," or "finishes" as used herein, shall include surface treatments, emulsions, enamels, paints, epoxy resins, and other protective coatings, excepting galvanizing or anodizing, whether used as a pretreatment, primer, intermediate coat, or finish coat.
 - 2. The term "DFT" means Dry Film Thickness.
- C. The following surfaces shall not be coated:
 - 1. Concrete, unless required by items on the concrete coating schedule below or the Drawings.
 - 2. Stainless steel
 - 3. Machined surfaces
 - 4. Grease fittings
 - 5. Glass
 - 6. Equipment nameplates
 - 7. Platform gratings, stair treads, door thresholds, and other walk surfaces, unless specifically indicated to be coated.
 - 8. Platform gratings, stair treads, door thresholds, and other walk surfaces, unless specifically indicated to be coated.
- D. The coating system schedules summarize the surfaces to be coated, the required surface preparation, and the coating systems to be applied. Coating notes on the Drawings are used to show or extend the limits of coating schedules, to show exceptions to the schedules, or to clarify or show details for application of the coating systems.

1.02 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

A. Reference Specifications

01 33 00	Submittal Procedures
01 60 00	Products, Materials, Equipment, and Substitutions

B. Reference Standards

ASTM International (ASTM)

HIGH-PERFORMANCE COATINGS

ASTM C309	Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete
ASTM D3276	Standard Guide for Painting Inspectors (Metal Substrates)
ASTM D4060	Abrasion Resistance of Organic Coatings by the Taber Abraser
ASTM D4262	Standard Test Method for pH of Chemically Cleaned or Etched Concrete Surfaces
ASTM D4263	Standard Test Method for Indicating Moisture in Concrete by the Plastic Sheet Method
ASTM D4417	Standard Test Methods for Field Measurement of Surface Profile of Blast Cleaned Steel
ASTM D6386	Standard Practice for Preparation of Zinc (Hot-Dip Galvanized) Coated Iron and Steel Product and Hardware Surfaces for Painting
ASTM F1869	Standard Test Method for Measuring Moisture Vapor Emission Rate of Concrete Subfloor Using Anhydrous Calcium Chloride
American Water Works Association (AWWA)	
AWWA D102	Coating Steel Water-Storage Tanks
ANSI/AWWA C105	Polyethylene Encasement for Ductile-Iron Pipe Systems
AWWA C213	Fusion-Bonded Epoxy Coating for the Interior and Exterior of Steel Water Pipelines
NACE International (NACE)	
NACE RP0287-02	Field Measurement of Surface Profile of Abrasive Blast-Cleaned Steel Surfaces Using a Replica Tape
Occupational Safety and Health Administration (OSHA)	
OSHA 29CFR1910.1200	Hazard Communication
Society for Protective Coatings (SSPC)	
SSPC Guide 12	Guide for Illumination of Industrial Painting Projects
SSPC PA 1	Shop, Field, and Maintenance Coating of Metals
SSPC PA Guide 11	Protecting Edges, Crevices, and Irregular Steel Surfaces by Stripe Coating
SSPC SP 1	Solvent Cleaning
SSPC SP 2	Hand Tool Cleaning
SSPC SP 3	Power Tool Cleaning
SSPC SP 5/NACE No. 1	White Metal Blast Cleaning
SSPC SP 6/NACE 3	Commercial Blast Cleaning
SSPC SP 7/NACE 4	Brush-off Blast Cleaning (NACE No. 4)
SSPC SP 10/NACE 2	Near-White Blast Cleaning
SSPC SP 11	Power Tool Cleaning to Bare Metal
SSP SP 13	Surface Preparation of Concrete

1.03 CONTRACTOR SUBMITTALS

A. Furnish submittals in accordance with Section 01 33 00 – Submittal Procedures.

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- B. Submittals shall include the following information and be submitted at least 30 Days prior to commencing protective coating Work:
1. Materials List: A copy of a coating materials list showing the manufacturer and the product number, keyed to the coating systems herein. The list shall be submitted prior to or at the time of submitting samples.
 2. Manufacturer's Information: For each coating system to be used, the following data:
 - a. Manufacturer's data sheet for each proposed product
 - b. Manufacturer's statements on the suitability of the proposed products for the intended use. Include in the statement confirmation that the coating manufacturer's technical engineering representative inspected all existing substrate and/or surfaces with existing coatings and confirmed that the proposed products, application procedures and surface preparation requirements are compatible with the coatings required by this Section.
 - c. Technical and performance information that demonstrates compliance with the system performance and material requirements.
 - d. Paint manufacturer's instructions and recommendations on surface preparation and application.
 - e. Colors available for each product (where applicable).
 - f. Compatibility of shop and field applied coatings (where applicable).
 - g. Safety Data Sheet for each product proposed.
- C. Samples
1. Samples of paint, finishes, and other coating materials shall be submitted on 8-1/2 inch by 11-inch sheet metal. Each sheet shall be completely coated over its entire surface with one protective coating material, type, and color.
 2. Two sets of color samples to match each color selected by the Engineer from the manufacturer's standard color sheets. If custom mixed colors are indicated, the color samples shall be made using color formulations prepared to match the color samples furnished by the Engineer.
- D. Experience Requirements of the Field Applicator:
1. Submit a project organization chart showing the full name and clear lines of responsibility and duties for all personnel scheduled to perform work (including office managers, quality control supervisor and safety supervisor) on the project.

2. Submit for documentation a statement on company letter head indicating the name of the Quality Control Supervisor (QCS) who has been given written authority by executive management to perform the duties of the QCS position for the project. Include in the statement the date of last successful completion of training to perform the QCS position. Acceptable coating inspection training programs include at a minimum: SSPC (PCI, NBPI, BCI) Level 1, KTA Level 1, GPI (Level 1), NACE (CIP Level 1, Frosio) or equivalent formal in-house inspection training conforming to ASTM D3276.
3. Submit for documentation the set of procedures that have been implemented for conducting and documenting training (as needed) and for qualifying trainees, newly hired craft workers and newly hired experienced workers. Include documentation of annual proficiency evaluation system for all craft workers.
4. Submit for documentation up-to-date experience, training certificates, and licenses for all personnel scheduled to perform work on the project.
5. Submit for documentation a statement on company letter head that key personnel (including but not limited to, project management and QCS) have reviewed the project contract documents and specifications in effect at contract award. Include in the statement confirmation that the project contract documents, and specifications have been distributed to all affected personnel within the organization scheduled to perform work on the project. Include in the statement the procedure for recording receipt and distribution of specifications and contract documents and all changes and revisions to contract documents. Include in the statement the procedures for documenting verbal responses from the Owner for requests for clarification.
6. Submit references of successfully completed projects for industrial coating projects completed within the last 18 calendar months. Acceptable references shall include contact information for owner staff having direct connection with the project, copies of facility owner project performance evaluations, letters of commendation from the owner or prime contractor, statements of final payment, and punch list acceptance.

E. Quality Assurance Plan

1. Submit for review the written project-specific Quality Control Program to be followed. Primary duties and responsibilities of the QCS as outlined in the Quality Control Program shall include but are not limited to the following:
 - a. Ensuring that qualified personnel perform the Work on the project.
 - b. Ensure that proper inspection forms and recording procedures are used for job quality monitoring (including those required herein).
 - c. Ensure correct and properly operating and calibrated equipment is used.
 - d. Review and sign off on Daily Inspection Reports (DIRs) on a timely basis (QCS must sign off or authorize review of DIRs by other competent QC personnel).
 - e. Ensure that Work is inspected for conformance with the contract requirements, good painting practice, and internal Quality Control (QC) procedures.
 - f. Ensure that nonconforming work and rework is properly documented.

- g. Develop and/or review Inspection and Test Plans.
 - h. Conduct and/or review internal audits.
2. Submit for documentation written project-specific procedures for all production processes to be used on the project. The procedures shall include, but are not limited to the following:
- a. Standard company or contract specific procedures are available to and used by on-site personnel for verifying that coating and related operations are performed in accordance with contract requirements and industry best practices.
 - b. Inspection procedures or project specific inspection plans ensuring that all work is properly performed and documented daily during coating operations or documented in accordance with contract requirements, are available to site personnel, and are used to perform in-process inspections of work at key hold points.
 - c. Abrasive blasting (dry or wet) and related processes
 - d. Water jetting and related processes
 - e. Hand and power tool cleaning and related processes
 - f. Coating mixing and related processes
 - g. Coating application (e.g., brush, roller, spray, mitt) and related processes
 - h. Top coating procedures (e.g., conditions when meeting and exceeding recoat windows)
 - i. Curing process for materials applied
 - j. Erecting, moving, and tearing down containment
 - k. Field audits performed on site confirming equipment is in good operating condition
3. Submit for review and documentation Daily Inspection Reports (DIRs) to Engineer on a weekly basis. All DIRs and testing results shall be maintained on file for the duration of the project. DIRs must be signed and dated by the Contractor and formally reviewed by the QCS. DIRs and other daily reports shall record project relevant observations including:
- a. Compressed air cleanliness
 - b. Air temperature (dry and wet bulb)
 - c. Relative humidity
 - d. Dew point
 - e. Substrate surface temperature

- f. Abrasive cleanliness
- g. Surface preparation cleanliness specified and achieved
- h. Surface profile specified and achieved
- i. Illumination of work area (foot candles for surface preparation, coating application, and inspection) in accordance with SSPC Guide 12 recommendations or contract requirements.
- j. Batch numbers of coatings and thinners
- k. Mixing of coatings (in accordance with coating manufacturer's mixing instructions)
- l. DFT readings for each applied coating meeting specification requirements.
- m. Inspection instruments used (manufacturer, model, and serial number)
- n. Storage temperature and storage conditions to include min/max daily, or as required.

1.04 SPECIAL CORRECTION OF DEFECTS REQUIREMENTS

- A. Nonconforming work, identified by Contractor QC personnel, Owner, Engineer, or Owner's Representative performing QA on behalf of the Owner shall be documented and repaired.
- B. Inspection: An inspection may be conducted during the eleventh month following completion of coating Work. The Contractor and a representative of the coating material manufacturer shall attend this inspection. Defective Work shall be repaired in accordance with these specifications and to the satisfaction of the Owner. The Owner may, by written notice to the Contractor, reschedule the inspection to another date within the one-year correction period or may cancel the inspection altogether. The Contractor is not relieved of its responsibilities to correct defects, whether or not the inspection is conducted.

1.05 COMPLIANCE WITH VOLATILE ORGANIC COMPOUND (VOC) LIMITS

- A. All paint and coating products shall comply with the applicable limits on volatile organic compounds (VOCs) as established by the United States Environmental Protection Agency and by state and local air quality regulating agencies. It shall be the Contractor's responsibility to verify compliance of all paints and coatings.
- B. Listed products in this specification are based on a maximum VOC level of 100 g/L. If local limits on VOCs are higher or lower, the Contractor shall propose substitute products that are compliant with local limits and equivalent in performance to the listed product. The Engineer shall determine if the proposed product is equivalent or equal to the named product in accordance with the requirements of Section 01 60 00 - Product, Materials, and Equipment Substitutions.

PART 2 -- PRODUCTS

2.01 GENERAL

- A. Suitability: The Contractor shall use suitable coating materials as recommended by the manufacturer.
- B. Material Sources: Where manufacturers and product numbers are listed, it is to show the type and quality of coatings that are required. If a named product does not comply with VOC limits in effect at the time of Bid opening, that product will not be accepted, and the Contractor shall propose a substitution product of equal quality that does comply. Proposed substitute materials will be considered as indicated below. Coating materials shall be materials that have a record of satisfactory performance in industrial plants, manufacturing facilities, and water and wastewater treatment plants.
- C. Compatibility: In any coating system only compatible materials from a single manufacturer shall be used in the Work. Particular attention shall be directed to compatibility of primers and finish coats. If necessary, a barrier coat shall be applied between existing prime coat and subsequent field coats to ensure compatibility.
- D. Containers: Coating materials shall be sealed in containers that plainly show the designated name, formula or specification number, batch number, color, date of manufacture, and name of manufacturer, all of which shall be plainly legible at the time of use.
- E. Colors: Colors and shades of colors of coatings shall be as indicated or selected by the Engineer. Each coat shall be of a slightly different shade to facilitate inspection of surface coverage of each coat. Finish colors shall be as selected from the manufacturer's standard color samples by the Engineer.
- F. Substitute or "Or-Equal" Products
 - 1. To establish equality under Section 01 60 00 - Products, Materials, Equipment and Substitutions, the Contractor shall furnish satisfactory documentation from the manufacturer of the proposed substitute or "or-equal" product that the material meets the indicated requirements and is equivalent or better in the following properties:
 - a. Suitability for the intended service
 - b. Compatibility with other coatings
 - c. Resistance to chemical attack
 - d. Minimum and maximum recoat times
 - e. Minimum and maximum cure time for immersion
 - f. Abrasion resistance per ASTM D4060 using CS17 Wheel
 - g. Maximum and minimum dry film thickness per coat
 - h. Temperature limitations during application and in service

2. Protective coating materials shall be standard products produced by recognized manufacturers who are regularly engaged in production of such materials for essentially identical service conditions. When requested, the Contractor shall provide the Engineer with the names of not less than 10 successful applications and case histories of the proposed manufacturer's products that comply with these requirements.
3. If a proposed substitution requires changes in the Work, the Contractor shall bear such costs involved as part of the Work.

2.02 INDUSTRIAL COATING SYSTEMS

A. System 1 - Acrylic Polymer

1. Materials

Primer	Manufacturer's recommendation
Finish Coat	1 component water-based acrylic
Type	Pure acrylic emulsion
Demonstrated suitable for	ferrous and nonferrous surfaces in industrial exposure, producing high gloss surface that is resistant to mild corrosion and chemical fumes, has good color and gloss retention, good weathering, and sunlight resistance
VOC Content, max (g/L)	100

2. Application and manufacturers

Prime Coat (DFT = 2 to 4 mils)	Finish Coat (DFT = 2 to 4 mils)	Total System DFT
PPG Pitt Tech Plus	PPG Pitt Tech Plus	4 to 8 mils
Tnemec Series V115 Unibond	Tnemec Series 1028 Enduratone for Gloss finish (use Series 1029 for Semi-Gloss finish)	
Carboline Sanitile 120	Carboline Carbocrylic 3359 DTMC	
Sherwin Williams Pro Industrial Procryl	Sherwin Williams Pro Industrial Acrylic	

B. System 2 - Organic Zinc/Epoxy/Polysiloxane

1. Materials

Primer	organic zinc
Intermediate coat	Epoxy
Finish Coat	
Type	Polysiloxane
Demonstrated suitable for	Long term outdoor exposure and color retention
VOC Content, max	100 grams per liter

2. Application and manufacturers

Prime Coat (DFT = 3 to 5 mils)	Intermediate Coat (DFT = 4 to 8 mils)	Finish Coat (DFT = 4 to 6 mils)	Total Min DFT
Sherwin Williams Corothane Galvapak 2K 100 MCU or Zinc Clad III HS 100	S-W Macropoxy 646-100 B58 Series	Sherloxane 800	11 mils
Carboline Carbozinc 859 VOC	Carboline Carboguard 890 VOC	Carboline Carboxane 2000	
PPG Amercoat 68HS VOC		PPG PSX 700	
Tnemec Series 94H2O HydroZinc	Tnemec Series L69 Hi- Build Epoxoline II	Tnemec Series 1061 Tnemec Topcoat	

C. System 3 - Not Used

D. System 4 - Epoxy/Polyurethane

1. Materials

Primer type	2 component epoxy
VOC Content, max (g/L)	100
Finish type	2 component aliphatic polyurethane
VOC Content, max (g/L)	100
Demonstrated suitable for	ferrous surfaces, superior color and gloss retention, exceptional resistance to weathering, chemical fumes, and splash

2. Application and manufacturers

Prime Coat (DFT = 3 - 5 mils)	Finish Coat (DFT = 3 - 4 mils)	Total System DFT
Carboline Carboguard 890 VOC	Carboline Carbothane 134 VOC	6 - 9 mils
Tnemec Hi-Build Epoxoline II Series L69	Tnemec Endura-Shield Series 1094 for Gloss finish (use Series 1095 for Semi-Gloss finish)	
PPG Amerlock 2/400 (VOC)	PPG Amershield VOC	
Sherwin Williams Macropoxy 646- 100	S W WB Acrolon 100	

E. System 5 - Not Used

F. System 6 - Not Used

G. System 7 - Not Used

H. System 8 - Epoxy, Equipment

1. Materials

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Primer Type	2 component epoxy
Demonstrated suitable for	Rust inhibitive, outstanding chemical, abrasion, and weathering resistance, resistance to splash, washdown, and condensation. Immersion capability is not required
VOC content, max (g/L)	100
Finish Type	2 component epoxy, available in many colors
Demonstrated suitable for	Outstanding chemical, abrasion, and weathering resistance, resistance to splash, washdown, and condensation. Immersion capability is not required
VOC content, max (g/L)	100

2. Application and manufacturers

Prime Coat (DFT = 4 - 5 mils)	Finish Coat (DFT = 4 - 5 mils)	Total System DFT
PPG- Amerlock 2/400 VOC	PPG Amerlock 2/400 VOC	8-10 mils
Tnemec Series L69	Tnemec Series L69	
Carboline Carboguard 890 VOC	Carboline Carboguard 890 VOC	
Sherwin Williams Macropoxy 646-100	Sherwin Williams Macropoxy 646-100	

I. System 9 - Not Used

J. System 10 - Acrylic, Concrete

1. Materials

Filler-Sealer Type	Epoxy or acrylic masonry sealer, for concrete and CMU, for wet and dry conditions
Primer	as recommended by manufacturer
VOC Content, max (g/L)	100
Finish Type	single component waterborne pure acrylic emulsion, industrial grade, high molecular weight
VOC Content, max (g/L)	100
Demonstrated suitable for	concrete under mild to moderate exposure conditions, splash but not immersion

2. Application and manufacturers

Prime Coat	Finish Coat	Total System DFT
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(Filler-Sealer)	(DFT = 5 - 7 mils) (2 or more coats)	
Tnemec EnviroFill Series 130	Tneme-Crete 180 Series	5 - 7 mils plus primer
PPG Amercoat 114A	PPG Pitt-Tech Plus Series	
Carboline Sanitile 500	Carboline - Carbocrylic 3359 DTMC	
Sherwin Williams Pro Industrial Heavy Duty Block Filler	Sherwin Williams Pro Industrial Acrylic	

K. System 11 - Not Used

L. System 12 – Not Used

2.03 SPECIAL COATING SYSTEMS

A. System 200 - PVC Tape: Prior to wrapping the pipe with PVC tape, the pipe and fittings first shall be primed using a primer recommended by the PVC tape manufacturer. After being primed, the pipe shall be wrapped with a 20-mil adhesive PVC tape, half-lapped, to a total thickness of 40 mils.

B. System 201 - Rich Portland Cement Mortar: Rich Portland cement mortar coating shall have a minimum thickness of 1/8-inch, followed by enclosure in an 8-mil thick polyethylene sheet with all joints and edges lapped and sealed with tape.

C. System 204 - Water Retardant, Concrete and Masonry

Type	silane-modified siloxane
Demonstrated suitable for	repelling water from vertical concrete and exterior masonry surfaces
VOC Content, max (g/L)	100
Products, or equal	Sherwin Williams H&C Super V (315 g/l) or Loxon 7 percent Siloxane Water Repellent (0 VOC)

D. System 205 - Polyethylene Encasement: Application of polyethylene encasement shall be in accordance with ANSI/AWWA C105 using Method C.

E. System 206 - Cement Mortar Coating: A 1-1/2-inch minimum thickness mortar coating reinforced with 3/4-inch galvanized welded wire fabric shall be provided. The cement mortar shall contain no less than one part Type V cement to 3 parts sand. The cement mortar shall be cured by a curing compound meeting the requirements of "Liquid Membrane Forming Compounds for Curing Concrete," ASTM C 309, Type II, white pigmented, or by enclosure in an 8-mil thick polyethylene sheet with all edges and joints lapped by at least 6-inches.

F. System 208 - Aluminum Metal Isolation

1. Material

Type	high build polyamide epoxy with chemical and abrasion resistance
Demonstrated suitable for	concrete and aluminum substrates, to isolate aluminum from contact with concrete and the resulting chemical degradation
VOC content, max (g/L)	100

2. Application and manufacturers

Coating (DFT = 16 - 20 mils)
Amerlock 2/400 VOC
Sherwin Williams Macropoxy 646-100
Tnemec Epoxoline Series L69
Carboline - Carboguard 890 VOC

G. System 209 - Not Used

PART 3 -- EXECUTION

3.01 MANUFACTURER'S SERVICES

- A. The Contractor shall require the protective coating manufacturer to furnish a qualified technical representative to visit the Site for technical support as may be necessary to resolve field problems.

3.02 WORKMANSHIP

- A. Skilled craftsmen and experienced supervision shall be used on coating Work.
- B. Coating shall be done in a workmanlike manner so as to produce an even film of uniform thickness. Edges, corners, crevices, and joints shall receive special attention to insure thorough surface preparation. The finished surfaces shall be free from runs, drops, ridges, waves, laps, brush marks, and variations in color, texture, and finish. The hiding shall be so complete that the addition of another coat would not increase the hiding. Special attention shall be given so that edges, corners, crevices, welds, and similar areas receive a film thickness equivalent to adjacent areas, and installations shall be protected by the use of drop cloths or other precautionary measures.
- C. Damage to other surfaces resulting from the Work shall be cleaned, repaired, and refinished to original condition.

3.03 STORAGE, MIXING, AND THINNING OF MATERIALS

- A. Manufacturer's Recommendations: Unless otherwise indicated, the coating manufacturer's printed recommendations and instructions for thinning, mixing, handling, applying, and protecting its coating materials, for preparation of surfaces for coating, and for other procedures relative to coating shall be strictly observed.

- B. Coating materials shall be used within the manufacturer's recommended shelf life.
- C. Storage and Mixing: Coating materials shall be stored under the conditions recommended by the Product Data Sheets, and shall be thoroughly stirred, strained, and kept at a uniform consistency during application. Coatings from different manufacturers shall not be mixed together.

3.04 PREPARATION FOR COATING

- A. General: Surfaces to receive protective coatings shall be prepared as indicated prior to application of coatings. The Contractor shall examine surfaces to be coated and shall correct surface defects before application of any coating material. Marred or abraded spots on shop-primed and on factory-finished surfaces shall receive touch-up restoration prior to any field coating application. Surfaces to be coated shall be dry and free of visible dust.
- B. Protection of Surfaces Not to be Coated: Surfaces that are not to receive protective coatings shall be protected during surface preparation, cleaning, and coating operations.
- C. Hardware, lighting fixtures, switch plates, machined surfaces, couplings, shafts, bearings, nameplates on machinery, and other surfaces not to be painted shall be removed, masked, or otherwise protected. Drop cloths shall be provided to prevent coating materials from falling on or marring adjacent surfaces. The working parts of mechanical and electrical equipment shall be protected from damage during surface preparation and coating operations. Openings in motors shall be masked to prevent entry of coating or other materials.
- D. Care shall be exercised not to damage adjacent Work during blasting operations. Spraying shall be conducted under carefully controlled conditions. The Contractor shall be fully responsible for and shall promptly repair any and all damage to adjacent Work or adjoining property occurring from blasting or coating operations.
- E. Protection of Painted Surfaces: Cleaning and coating shall be coordinated so that dust and other contaminants from the preparation process will not fall on wet, newly-coated surfaces.

3.05 ENVIRONMENTAL REQUIREMENTS

- A. No coating work shall be performed under the following conditions:
 - 1. Surface or ambient temperatures exceed the manufacturer's recommended maximum or minimum allowable.
 - 2. Dust or smoke laden atmosphere.
 - 3. Damp or humid conditions, where the relative humidity is above the manufacturer's maximum allowable.
 - 4. Substrate and ambient temperatures are less than 5°F above the dew point and are decreasing. Dew point shall be measured by use of an instrument such as a Sling Psychrometer in conjunction with U.S. Department of Commerce, Weather Bureau psychrometric tables. Elcometer 319 Dew Point meter or equal may also be used.

5. Ambient temperature that is expected to drop below 50 degrees F or less than 5 degrees F above the dew point within 8 hours after application of coating.

3.06 SURFACE PREPARATION STANDARDS

- A. The following referenced surface preparation specifications of the Steel Structures Painting Council shall form a part of this specification:
 1. Solvent Cleaning (SSPC SP 1): Removal of oil, grease, soil, salts, and other soluble contaminants by cleaning with solvent, vapor, alkali, emulsion, or steam.
 2. Hand Tool Cleaning (SSPC SP 2): Removal of loose rust, loose mill scale, loose paint, and other loose detrimental foreign matter, by hand chipping, scraping, sanding, and wire brushing.
 3. Power Tool Cleaning (SSPC SP 3): Removal of loose rust, loose mill scale, loose paint, and other loose detrimental foreign matter, by power tool chipping, descaling, sanding, wire brushing, and grinding.
 4. White Metal Blast Cleaning (SSPC SP 5/NACE 1): Removal of all visible rust, oil, grease, soil, dust, mill scale, paint, oxides, corrosion products and foreign matter by blast cleaning.
 5. Commercial Blast Cleaning (SSPC SP 6/NACE 3): Removal of all visible oil, grease, soil, dust, mill scale, rust, paint, oxides, corrosion products, and other foreign matter, except that staining shall be limited to no more than 33 percent of each square inch of surface area.
 6. Brush-Off Blast Cleaning (SSPC SP 7/NACE 4): Removal of all visible oil, grease, soil, dust, loose mill scale, loose rust, and loose paint.
 7. Near-White Blast Cleaning (SSPC SP 10/NACE 2): Removal of all visible oil, grease, soil, dust, mill scale, rust, paint, oxides, corrosion products, and other foreign matter, except that staining shall be limited to no more than 5 percent of each square inch of surface area.
 8. Power Tool Cleaning to Bare Metal (SSPC 11) When viewed without magnification, the surface shall be free of all visible oil, grease, dirt, dust, mill scale, rust, paint, oxides, corrosion products, and other foreign matter. Slight residues of rust and paint may be left in the lower portion of pits if the original surface is pitted. The surface profile shall not be less than 1 mil (25 microns).
 9. Surface Preparation of Concrete (SSPC-SP 13/NACE 6): Removal of protrusions, laitance and efflorescence, existing coatings, form-release agents, and surface contamination by detergent or steam cleaning, abrasive blasting, water jetting, or impact or power tool methods as appropriate for the condition of the surface and the requirements of the coating system.

3.07 FERROUS METAL SURFACE PREPARATION (UNGALVANIZED)

- A. The minimum abrasive blasting surface preparation shall be as indicated in the coating system schedules included at the end of this Section. Where there is a conflict between these requirements and the coating manufacturer's printed recommendations for the intended service, the higher degree of cleaning shall apply.

- B. The Shop Painting Facility shall use a minimum blast material mixture of 75 percent grit and 25 percent shot material to achieve the proper surface profile.
- C. The Field Coating Applicator shall abrasive blast the shop coated surfaces per SSPC SP 7/NACE 4. The previously shop-painted surfaces shall be abraded prior to the application of the final coats. Special attention shall be given to uncoated steel weld joints, coating holdbacks, and bare metal.
- D. Grease, oil, and welding fluxes shall be removed by wiping with MEK or naphtha cleaning or with trisodium phosphate detergent per SSPC SP 1.
- E. All sharp edges shall be rounded or chamfered and all burrs, rust, scale, welding slag, and spatter shall be removed, and the surface prepared by SSPC SP 2 hand tool cleaning, and SSPC SP 3 power tool cleaning.
- F. The Contractor shall test the surfaces for soluble salts with the use of Chlor*Test as manufactured by Chlor*Rid International or approved equivalent. Any blasted surfaces shall be tested and shall have a maximum concentration of 5 micrograms per square centimeter ($\mu\text{g}/\text{cm}^2$). A test shall be conducted for every 100 square feet (ft^2) of surface area to be coated at locations determined by the Inspector.
- G. If the soluble salt test indicates chloride concentrations greater than those outlined in these Specifications, the Contractor shall use Chlor*Rid, as manufactured by Chlor*Rid International, in the water source during Water Cleaning to remove the salts from the substrate. A substrate's surface preparation will be accepted once the soluble salt concentration is below the amounts outlined in these Specifications.
- H. The type and size of abrasive shall be selected to produce a surface profile that meets the coating manufacturer's recommendation for the particular coating and service conditions. Abrasive shall not be reused unless an automated blasting system is used for surfaces that will be in non-submerged service. For automated blasting systems, clean oil-free abrasives shall be maintained. The abrasive mix shall include at least 50 percent grit.
- I. The Contractor shall comply with the applicable federal, state, and local air pollution control regulations for blast cleaning.
- J. Compressed air for air blast cleaning shall be supplied at adequate pressure from well-maintained compressors equipped with oil and moisture separators that remove at least 95 percent of the contaminants.
- K. Surfaces shall be cleaned of dust and residual particles of the cleaning operation by dry air blast cleaning, vacuuming, or another approved method prior to painting.
- L. Enclosed areas and other areas where dust settling is a problem shall be vacuum-cleaned and wiped with a tack cloth.
- M. Damaged or defective coating shall be removed by the blast cleaning to meet the clean surface requirements before recoating.
- N. If the required abrasive blast cleaning will damage adjacent Work, the area to be cleaned is less than 100 square feet, and the coated surface will not be submerged in service, then SSPC SP 2 or SSPC SP 3 may be used.

- O. Shop-applied coatings of unknown composition shall be completely removed before the indicated coatings are applied. Valves, castings, ductile or cast iron pipe, and fabricated pipe or equipment shall be examined for the presence of shop-applied temporary coatings. Temporary coatings shall be completely removed by solvent cleaning per SSPC SP 1 before the abrasive blast cleaning has been started.
- P. Shop primed equipment shall be solvent-cleaned in the field before finish coats are applied.

3.08 FERROUS METAL SURFACE PREPARATION (GALVANIZED)

- A. Galvanized ferrous metal shall be alkaline cleaned per SSPC SP 1 to remove oil, grease, and other contaminants detrimental to adhesion of the protective coating system, followed by brush off blast cleaning per SSPC SP 7/NACE 4.
- B. Any high spots, sharp protrusions, and rough edges, such as the metal drip line, shall be smoothed to avoid paint film gaps in the areas of the high spots. Surfaces shall be hand tool cleaned per SSPC SP 2 and power tool cleaned per SSPC SP 3.
- C. Pretreatment coatings of surfaces shall be in accordance with the printed recommendations of the coating manufacturer. Galvanized metals may be cleaned with suitable organic solvent such as a rust inhibitor or aqueous alkaline solution per ASTM D6386.
- D. The surfaces of galvanized steel exposed to chemical splashing or within a wastewater head space shall be abraded per SSPC SP 11 or SP 7 prior to coating.

3.09 SURFACE PREPARATION OF FERROUS SURFACES WITH EXISTING COATINGS, EXCLUDING STEEL RESERVOIR INTERIORS

- A. General: Grease, oil, heavy chalk, dirt, or other contaminants shall be removed by solvent or detergent cleaning prior to abrasive blast cleaning. The generic type of the existing coatings shall be determined by laboratory testing.
- B. Abrasive Blast Cleaning: The Contractor shall provide the degree of cleaning indicated in the coating system schedule for the entire surface to be coated. If the degree of cleaning is not indicated in the schedule, deteriorated coatings shall be removed by abrasive blast cleaning to SSPC SP 6/NACE 3. Areas of tightly adhering coatings shall be cleaned to SSPC SP 7/NACE 4, with the remaining thickness of existing coating not to exceed 3-mils.
- C. Incompatible Coatings: If coatings to be applied are not compatible with existing coatings the Contractor shall apply intermediate coatings per the manufacturer's recommendation for the indicated coating system or shall completely remove the existing coating prior to abrasive blast cleaning. A small trial application shall be conducted for compatibility prior to painting large areas.
- D. Unknown Coatings: Coatings of unknown composition shall be completely removed prior to application of new coatings.

3.10 CONCRETE AND CONCRETE BLOCK MASONRY SURFACE PREPARATION

- A. Surface preparation shall not begin until at least 30 Days after the concrete or masonry has been placed. All water retaining structures shall be successfully leak tested prior to coating application.

- B. At the discretion of the Inspector, the Contractor shall test the surfaces for soluble salts with the use of Chlor*Test as manufactured by Chlor*Rid International or approved equivalent. Any surfaces shall be tested and shall have a maximum concentration of 5 micrograms per square centimeter ($\mu\text{g}/\text{cm}^2$). A test shall be conducted for every 100 square feet (ft^2) of surface area to be coated at locations determined by the Inspector.
- C. If the soluble salt test indicates chloride concentrations greater than those outlined in these Specifications, the Contractor shall use Chlor*Rid, as manufactured by Chlor*Rid International, in the water source during Water Cleaning to remove the salts from the substrate. A substrate's surface preparation will be accepted once the soluble salt concentration is below the amounts outlined in these Specifications.
- D. In accordance with ASTM D4262, test to determine the pH of the concrete surface after the surface has been thoroughly blasted and cleaned. If the pH is outside the range recommended by the coating manufacturer, then the surface must be neutralized by removing concrete until the surface pH of 7 or greater is obtained prior to any coating application. One pH test shall be performed every 200 square feet, or less, and at locations determined by the Inspector.
- E. The Contractor shall test for capillary moisture in accordance with ASTM D4263. Moisture tests shall be taken every 200 square feet or less and at locations determined by the Inspector. If capillary moisture is present, the coating manufacturer shall be consulted to determine primer requirements and special coating application criteria.
- F. For below grade structures with surface areas greater than 2,000 square feet, the Contractor shall install three anhydrous calcium chloride test kits on bare concrete to measure the Moisture Vapor Transmission Rate (MVTR) on a flat horizontal surface. Testing and calculations shall be performed according to ASTM F1869. The MVTR shall be less than 3 lbs per 1,000 square feet per 24 hours. If the MVTR is greater than 3 lbs per 1,000 square feet per 24 hours, the Contractor shall apply a concrete sealant to reduce the MVTR through the concrete. The test kits shall be undisturbed for a minimum of 60 hours.
- G. Surface Voids: Bugholes, honeycomb, or other surface voids greater than 1/4 inch in depth or 1/4 inch in diameter shall be filled in with a resurfacing mortar prior to the application of any primer or finish coat.
- H. Holes or other joint defects in masonry shall be filled with mortar and repainted. All voids and cracks shall be repaired as specified. Loose or spatter mortar shall be removed by scraping and chipping. Masonry surfaces shall be cleaned with clear water by washing and scrubbing to remove foreign and deleterious substances. Muriatic acid shall not be used. After cleaning, masonry surfaces shall be sealed or filled with a sealer or block filler compatible with the specified primer.
- I. Coating Pipe Penetrations: A 1/4-inch wide by 3/8-inch deep saw cut shall be made around the circumference of the pipe as it penetrates the concrete. Prior to the coating application, the saw cut shall be dried and vacuumed to remove all dust and residue.
- J. Coating Floor/Wall Joints: A 1/4-inch wide by 3/8-inch deep saw cut shall be made on the vertical and horizontal concrete surfaces around the perimeter of the floor. The saw cut shall be 2 inches from the joint on both sides. Prior to the coating application, the saw cut shall be dried and vacuumed to remove all dust and residue.
- K. All oil, grease, and form release and curing compounds shall be removed by detergent cleaning per SSPC-SP 1 before abrasive blast cleaning.

- L. New concrete, concrete block masonry surfaces and deteriorated concrete surfaces to be coated shall be abrasive blast cleaned to remove existing coatings, laitance, and deteriorated concrete, and to roughen the surface equivalent to 80 Grit sandpaper or ICRI No. 310.2 Guideline for Selecting and Specifying Concrete Surface Preparation for Sealers, Coatings, and Polymer Overlays Concrete Surface Profile No. 4.
- M. Surfaces shall be clean and as recommended by the coating manufacturer before coating is started.
- N. Secondary Containment: Treat cracks, construction joints, expansion joints and inside corners according to the coating manufacturer's recommendations.

3.11 PLASTIC, FIBER GLASS AND NONFERROUS METALS SURFACE PREPARATION

- A. Plastic and fiber glass surfaces shall be sanded or brush off blast cleaned prior to solvent cleaning with a chemical compatible with the coating system primer.
- B. Non-ferrous metal surfaces shall be solvent-cleaned SSPC SP 1 followed by sanding or brush-off blast cleaning SSPC SP 7/NACE 4.
- C. Surfaces shall be clean and dry prior to coating application.

3.12 ARCHITECTURAL CONCRETE BLOCK MASONRY SURFACE PREPARATION

- A. The mortar surfaces shall be cured at least 14 Days before surface preparation Work is started.
- B. Dust, dirt, grease, and other foreign matter shall be removed prior to abrasive blasting.
- C. The masonry surfaces shall be prepared in accordance with the material manufacturer's printed instructions.

3.13 SHOP COATING REQUIREMENTS

- A. Unless otherwise indicated, items of equipment or parts of equipment which are not submerged in service shall be shop-primed and then finish-coated in the field after installation with the indicated or selected color. The methods, materials, application equipment, and other details of shop painting shall comply with this Section. If the shop primer requires top coating within a specific period of time, the equipment shall be finish-coated in the shop and then be touched up after installation.
- B. Items of equipment or parts and surfaces of equipment which are submerged or inside an enclosed hydraulic structure when in service, with the exception of pumps and valves, shall have surface preparation and coating performed in the field.
- C. Shop primed surfaces which are to be incorporated in the work shall be prepared in the field by cleaning all surfaces as necessary in accordance with SSPC SP 1 and SP 2. Damaged shop coating shall be cleaned in accordance with SSPC SP 3, Power Tool Cleaning, and recoated with the primer specified.

- D. For every 500 square feet, or less, of steel surface blasted, the surface profile shall be tested with the use of Press-o-Film as manufactured by Testex, or other RP0287 approved equal, at locations to be determined by the Inspector. The replica tape thickness shall be measured using a dial micrometer manufactured by Testex, or other ASTM D4417 Type C approved equal. For each test area, one replica tape test shall be performed. For each test area, the three replica tape thickness values shall be recorded and must be within 10 percent of the coating manufacturer's recommended profile. If the surface profile does not meet the manufacturer's recommended profile, two additional tests will be performed within a 12-inch diameter of the initial test. If the values are not satisfactory, the Contractor shall reblast the affected areas.
- E. The interior surfaces of steel water reservoirs, except for Paragraph A surfaces, shall have surface preparation and coating Work performed in the field.
- F. For certain pieces of equipment, it may be undesirable or impractical to apply finish coatings in the field. Such equipment may include engine generator sets, equipment such as electrical control panels, switchgear or main control boards, submerged parts of pumps, ferrous metal passages in valves, or other items where it is not possible to obtain the indicated quality in the field. Such equipment shall be primed and finish-coated in the shop and touched up in the field with the identical material after installation. The Contractor shall require the manufacturer of each such piece of equipment to certify as part of its Shop Drawings that the surface preparation is in accordance with these specifications. The coating material data sheet shall be submitted with the Shop Drawings for the equipment.
- G. For certain small pieces of equipment, the manufacturer may have a standard coating system that is suitable for the intended service conditions. In such cases, the final determination of suitability will be made during review of the Shop Drawing submittals. Equipment of this type generally includes only indoor equipment such as instruments, small compressors, and chemical metering pumps.
- H. Shop-painted surfaces shall be protected during shipment and handling by suitable provisions including padding, blocking, and the use of canvas or nylon slings. Primed surfaces shall not be exposed to the weather for more than 2 months before being top coated or less time if recommended by the coating manufacturer.
- I. Damage to shop-applied coatings shall be repaired in accordance with this Section and the coating manufacturer's printed instructions.
- J. The Contractor shall make certain that the shop primers and field topcoats are compatible and meet the requirements of this Section. Copies of applicable coating manufacturer's data sheets shall be submitted with equipment Shop Drawings.

3.14 APPLICATION OF COATINGS

- A. The application of protective coatings to steel substrates shall be in accordance with SSPC PA 1 - Paint Application Specification No. 1.
- B. Cleaned surfaces and each coat shall be inspected prior to applying each succeeding coat. The Contractor shall schedule such inspection with the Engineer in advance.
- C. Blast cleaned ferrous metal surfaces shall be painted before any rusting or other deterioration of the surface occurs. Blast cleaning shall be limited to only those surfaces that can be coated in the same day.

- D. Coatings shall be applied in accordance with the manufacturer's instructions and recommendations and this Section, whichever has the most stringent requirements.
- E. Special attention shall be given to edges, angles, weld seams, flanges, nuts and bolts, and other places where insufficient film thicknesses are likely to be present. Contractor shall use an independent stripe coat per SSPC PA Guide 11 for these areas. Particular care shall be used to ensure that the specified coverage is secured on the edges and corners of all surfaces.
- F. Special attention shall be given to materials that will be joined so closely that proper surface preparation and application are not possible. Such contact surfaces shall be coated prior to assembly or installation.
- G. Finish coats, including touch-up and damage repair coats shall be applied in a manner that will present a uniform texture and color matched appearance.
- H. Coatings shall not be applied under the following conditions:
 - 1. Temperatures exceeding the manufacturer's recommended maximum and minimum allowable.
 - 2. Concrete surfaces will be in direct sunlight during application or within 3 hours after application.
 - 3. Dust or smoke laden atmosphere.
 - 4. Damp or humid weather.
 - 5. Substrate or air temperature is less than 5 degrees F above the dew point.
 - 6. Air temperature is expected to drop below 40 degrees F or less than 5 degrees F above the dew point within 8 hours after application of coating.
 - 7. Wind conditions are not calm.
- I. Dew point shall be determined by use of a sling psychrometer in conjunction with U.S. Dept. of Commerce, Weather Bureau psychrometric tables.
- J. Unburied steel piping shall be abrasive blast cleaned and primed before installation.
- K. Finish coats shall be applied after concrete, masonry, and equipment installation is complete, and the working areas are clean and dust free.

3.15 CURING OF COATINGS

- A. The Contractor shall maintain curing conditions in accordance with the conditions recommended by the coating material manufacturer or by this Section, whichever is the most stringent, prior to placing the completed coating system into service.
- B. In the case of enclosed areas, forced air ventilation, using heated air if necessary, may be required until the coatings have fully cured.

3.16 IDENTIFICATION OF PIPING

- A. Every valve or connection, where it may be possible for a worker to be exposed to a hazardous substance, shall be labeled per OSHA Occupational Safety and Health Standards 29CFR1910.1200.
- B. Unburied pipes in structures and in chemical pipe trenches shall be color-code painted. Colors shall be as selected by the Engineer or as indicated.

3.17 SHOP AND FIELD INSPECTION AND TESTING

- A. General: The Contractor shall give the Engineer a minimum of 3 Days advance notice of the start of any field surface preparation or coating application, and a minimum of 7 Days advance notice of the start of any surface preparation activity in the shop.
- B. Such Work shall be performed only in the presence of the Engineer, unless the Engineer has granted prior approval to perform such Work in its absence.
- C. Inspection by the Engineer, or the waiver of inspection of any particular portion of the Work, shall not relieve the Contractor of its responsibility to perform the Work in accordance with these Specifications.
- D. Scaffolding shall be erected and moved to locations where requested by the Engineer to facilitate inspection. Additional illumination shall be furnished on areas to be inspected.
- E. Inspection Devices: The Contractor shall furnish inspection devices in good working condition for the detection of holidays and measurement of dry film thicknesses of coatings. Dry-film thickness gauges shall be made available for the Engineer's use while coating is being done, until final acceptance of such coatings. The Contractor shall furnish the services of a trained operator of the holiday detection devices until the final acceptance of such coatings. Holiday detection devices shall be operated only in the presence of the Engineer.
- F. Holiday Testing: The Contractor shall test for continuity all coated ferrous surfaces inside a steel reservoir, other surfaces that will be submerged in water or other liquids, surfaces that are enclosed in a vapor space in such structures, and surfaces coated with any of the submerged and severe service coating systems. Areas that contain discontinuities shall be marked and repaired or recoated in accordance with the coating manufacturer's printed instructions and then be retested.
 - 1. Coatings with thickness exceeding 20-mils total DFT: Pulse-type holiday detector such as **Tinker & Rasor Model AP-W, D.E. Stearns Co. Model 14/20**, or equal shall be used. The unit shall be adjusted to operate at the voltage required to cause a spark jump across an air gap equal to twice the required coating thickness.
 - 2. Coatings with thickness of 20-mils or less total DFT: **Tinker & Rasor Model M1** non-destructive type holiday detector, **K-D Bird Dog**, or equal shall be used. The unit shall operate at less than 75 volts. For thicknesses between 10- and 20-mils, a non-sudsing type wetting agent, such as **Kodak Photo-Flo** or equal, shall be added to the water prior to wetting the detector sponge.

G. Film Thickness Testing: On ferrous metals, the dry film coating thickness shall be measured in accordance with the SSPC Paint Application Specification No. 2 using a magnetic type dry film thickness gauge such as **Mikrotest Model FM, Elcometer Model 111/1EZ**, or equal. Each coat shall be tested for the correct thickness. No measurements shall be made until at least 8 hours after application of the coating. On non-ferrous metals and other substrates, the coating thicknesses shall be measured at the time of application using a wet film gauge.

H. Surface Preparation: Confirm proper surface profile with Testex Press-O-Film replica tape in accordance with NACE RP0287-02.

3.18 COATING SYSTEM SCHEDULE, FERROUS METAL - NOT GALVANIZED

	Item	Surface Prep.	System No.
FM-1	All surfaces indoors and outdoors, exposed or covered, including structural steel, miscellaneous metalwork, and supports for prefabricated metal buildings.	Commercial blast cleaning SSPC SP 6/NACE 3	(1) Acrylic Polymer

FM-17	Surfaces of indoor equipment, not submerged	Commercial blast cleaning SSPC SP 6/NACE 3	(8) epoxy, equipment
FM-19	Buried pipe couplings, valves, fittings, and flanged joints (where piping is plastic).	Removal of dirt, grease, oil	(201) rich portland cement mortar
FM-20	Buried pipe couplings, valves, and flanged joints (where piping is ductile or cast iron, not tape-coated), including factory-coated surfaces.	As specified by reference specification	(205) polyethylene encasement
FM-21	Buried pipe couplings, valves, and flanged joints (where piping is mortar-coated steel or reinforced concrete), including factory-coated surfaces.	Removal of dirt, grease, oil	(206) cement mortar coating

3.19 COATING SYSTEM SCHEDULE, FERROUS METAL - GALVANIZED: PRETREATMENT COATINGS, BARRIER COATINGS, OR WASHES SHALL BE APPLIED AS RECOMMENDED BY THE COATING MANUFACTURER. ALL GALVANIZED SURFACES SHALL BE COATED EXCEPT FOR THE FOLLOWING ITEMS WHICH SHALL BE COATED ONLY IF REQUIRED BY OTHER SECTIONS: (1) FLOOR GRATINGS AND FRAMES, (2) HANDRAILS, (3) STAIR TREADS, (4) CHAIN LINK FENCING AND APPURTENANCES.

	Item	Surface Prep.	System No.
FMG-1	All exposed surfaces indoors and outdoors, except those included below.	Solvent cleaning SSPC SP 1	(1) Acrylic Polymer

FMG-3	Buried small steel pipe.	Removal of dirt, grease, oil	(200) PVC tape

3.20 COATING SYSTEM SCHEDULE, STEEL WATER RESERVOIR INTERIOR: FOR STEEL WATER RESERVOIR EXTERIOR COATING SYSTEM, SEE "COATING SYSTEM SCHEDULE, FERROUS METAL-NOT GALVANIZED." THE INTERIOR SURFACES OF STEEL WATER RESERVOIRS SHALL HAVE SURFACE PREPARATION AND COATING WORK PERFORMED IN THE FIELD.

	Item	Surface Prep.	System No.
SR-1	Interior surfaces including plates, lap roof plate edges (both sides), roof structural members, fittings, piping within the reservoir, and vents, undersides of column bases, floor under column bases before columns have been set in place, submerged contact surfaces that are not accessible after erection. The interior and exterior surfaces of the overflow, drain, inlet, outlet, and all piping under the reservoir shall be coated in accordance with the requirements of Division 33.	SSPC SP 10/NACE 2	(105) Epoxy, Steel Reservoirs

3.21 COATING SYSTEM SCHEDULE, NON-FERROUS METAL, PLASTIC, FIBER GLASS

- A. Where isolated non-ferrous parts are associated with equipment or piping, the Contractor shall use the coating system for the adjacent connected surfaces. Do not coat handrails, gratings, frames or hatches. Only primers recommended by the coating manufacturer shall be used.

	Item	Surface Prep.	System No.
NFS-1	All exposed surfaces, indoors and outdoors, except those included below.	Solvent cleaned SSPC SP 1	(1) Acrylic Polymer
NFS-3	Aluminum surfaces in contact with concrete, or with any other metal except galvanized ferrous metal.	Solvent cleaned SSPC	(208) aluminum metal isolation
NFS-4	Polyvinyl chloride plastic piping, indoors and outdoors, or in structures, not submerged.	Solvent cleaned SSPC	(1) Acrylic Polymer

HIGH-PERFORMANCE COATINGS

NFS-6	Buried non-ferrous metal pipe.	Removal of dirt, grease, oil	(200) PVC tape

3.22 COATING SYSTEM SCHEDULE-CONCRETE BLOCK MASONRY

	Item	Surface Prep.	System No.
CBM-1	All surfaces, indoors and outdoors, where indicated.	Per paragraph 3.10	(10) acrylic, concrete

END OF SECTION

SECTION 10 14 00 – SIGNAGE

PART 1 -- GENERAL

1.01 SUMMARY

A. Section Includes:

1. Building signages

1.02 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

A. Reference Specifications

01 33 00	Submittal Procedures
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B. Reference Standards

Americans with Disabilities Act (ADA): ADA Accessibility Guidelines (ADAAG)	
Building Code	
	Refer to the Drawings to determine which Building Code applies. The applicable Building Code, defined by the Drawings, is referred to herein as “the Code.”
National Fire Protection Association (NFPA)	
NFPA 704	Identification of the Hazards of Materials for Emergency Response
Occupational Safety and Health Administration (OSHA)	

1.03 SUBMITTALS

- A. Product Furnish submittals in accordance with Section 01 33 00 – Submittal Procedures

1.04 ACTION SUBMITTALS

A. Product Data:

1. Manufacturer’s specifications, technical data, installation methods, and maintenance instructions, and the following:
 - a. Manufacturer’s full range color charts, indicating custom color availability for color selection by Owner.

B. Certificates:

1. Certification by the building signage Manufacturer that the building signage provided is suitable for, and compatible with, the required installation.
2. Certification by the building signage Manufacturer that the building signage provided is suitable for, and compatible with, the substrates and surfaces indicated.
3. Certification of Manufacturer qualifications demonstrating compliance with the qualifications requirements indicated.

SIGNAGE

4. When requested by the Engineer, furnish other certifications as may be required to demonstrate compliance with the Contract Documents.

C. Shop Drawings:

1. Complete Shop Drawings showing location and detail of installation.
2. Shop Drawings shall be drawn to sufficient scale and shall include dimensions, show elevations and details of construction of each building signage type, schedule of building signage, mounting details, location and installation requirements, thickness of materials, joints, provisions for expansion and contraction, connections, accessories, and trim.

D. Samples:

1. The Contractor shall submit 2 samples of each of the following. Unless otherwise indicated, samples shall be full size and shall show gauges, configuration, construction, finish and color proposed for the various components. Samples shall be clearly marked to show the Manufacturer's name, product identification, finish and color. New samples shall be resubmitted of each, as required, until approved by the Engineer. Upon approval, the samples shall become the standard for acceptance for the project with regard to color, finish, and quality of each item. Approval of samples shall not relieve the Contractor from compliance with the Contract Documents.
2. Full-size sample of each typical building signage type.

1.05 CLOSEOUT SUBMITTALS

A. Warranty:

1. Submit copy of the warranty.

1.06 QUALITY ASSURANCE

A. Single Source Responsibility:

1. Building signage shall be provided by a single Manufacturer, unless otherwise indicated.

B. Qualifications:

1. Manufacturers:
 - a. Building signage Manufacturer shall have a minimum of 10 years of building signage manufacturing experience.
 - b. Manufacturers without these qualifications will not be accepted.

1.07 WARRANTY

A. Manufacturer Warranty:

1. Furnish Manufacturer's 15-year written warranty to cover defects in materials, products, and manufacturing workmanship.

SIGNAGE

- a. Warranty shall include coverage against chipping, fading, rusting, shattering, or peeling.
2. Warranties shall be non-prorated for the entire warranty period.
3. The term of the warranties shall begin on the date of Substantial Completion.

PART 2 -- PRODUCTS

2.01 GENERAL

- A. Building signage shall be recommended by the Manufacturer for the installation indicated.
- B. Building signage shall be suitable for, and compatible with, the required installation.
- C. Building signage shall be suitable for, and compatible with, the substrates and surfaces indicated.

2.02 RESTROOM SIGNS

- A. Manufacturer and Product, or Equal:
 1. Subject to the requirements indicated, provide Manufacturer and product listed below, or equal:
 - a. SignEtch I Series by ASI-Signage
- B. Description:
 1. Signs shall consist of raised braille characters and conform to ADAAG.
 2. Signs shall be 8-in by 8-in by 0.125-in aluminum with brushed square edges. Raised surfaces shall have a brushed finish and recessed surfaces shall be painted black, or color as selected by the Owner. Signs shall be provided with a top coat of urethane spray containing UV inhibitors and antioxidant compounds, and shall be rated for interior and exterior use.
 3. Unless otherwise noted, all lettering shall be Helvetica Medium in both upper and lower case, as specified and scheduled.
 4. Signs shall be mounted as scheduled, as recommended in writing by the Manufacturer, and as approved by the Engineer.

2.03 RESTRICTIVE/CAUTION SIGNS

- A. Manufacturer and Product, or Equal:
 1. Subject to the requirements indicated, provide Manufacturer and product listed below, or equal:
 - a. Seton UltraTuff by Seton
 - b. Branford, Connecticut
- B. Description:

SIGNAGE

1. Signs shall be constructed of a printed polyester film permanently bonded to a rigid fiberglass panel and over-laminated with Tedlar by Seton, or approved equal, and a total thickness of 0.11-in minimum.
2. Signs shall be 14-in wide by 10-in tall in rounded corners. Color of signs and letters shall be in accordance with OSHA standards. All other aspects of the Restrictive/Caution Signs shall be in accordance with OSHA standards. If OSHA standards do not apply, the color shall be red with white letters, 1-in high.
3. Signs shall be wall and door surface mounted per Manufacturer standard. Signs shall be mounted as scheduled, as recommended in writing by the Manufacturer, and as approved by the Engineer.
4. Sign sizes shall be adjusted to suit the number of letters in each sign with a 1 ½-in minimum border all around. Two lines are permitted. Center justify the letters.

2.04 BUILDING SIGNS

A. Manufacturer and Product, or Equal:

1. Subject to the requirements indicated, provide Manufacturer and product listed below, or equal.
 - a. Seton Identification Products; Fiberglass, Style No. M0027.

B. Description:

1. Signs shall be high performance fiberglass, constructed of a printed polyester film permanently bonded to a rigid fiberglass panel and over-laminated with a total thickness of 0.10-in minimum.
2. Signs shall be suitable for interior or exterior use, and resist UV light, dirt, and harsh chemicals.
3. Signs shall be 14-in wide by 10-in tall with rounded corners. Colors, letters, and other aspects of the signs shall be in accordance with OSHA standards. If OSHA standards do not apply, the color shall be red selected by the Engineer, unless otherwise indicated.
4. Sign sizes shall be adjusted to suit the number of letters in each sign with a 1 ½-in minimum border. Two lines are permitted. Letters shall be left justified.

PART 3 -- EXECUTION

3.01 DELIVERY, STORAGE, AND HANDLING

- A. Deliver materials to Site in Manufacturer's original, unopened packages, containers, or bundles with labels intact, which clearly identify contents.
- B. Store materials carefully in accordance with the Manufacturer's written instructions, in an area that is protected from deleterious elements, and in a manner that will prevent damage to the products.
- C. Handle materials in strict accordance with Manufacturer's written instructions.

SIGNAGE

3.02 LOCATIONS

- A. Signage shall be installed at the locations indicated or as otherwise required by the Code and OSHA. Where a conflict occurs between the requirements of this Section and the references herein, the more stringent shall apply, as directed by the Engineer.
- B. Where not indicated, signs shall be installed as directed by the Engineer.
- C. Signs shall be mounted 60-in above the floor, unless otherwise indicated.

3.03 PROJECT CONDITIONS

- A. Comply with Manufacturer's written instructions for environmental conditions before, during, and after installation.
- B. Protect surrounding Work from damage that may result from operations under this Section.

3.04 INSPECTION

- A. The Contractor shall be totally responsible for the proper performance and completion of the Work under this Section.
- B. Systems and components shall be inspected before installation.
 - 1. Damaged or defective items shall be rejected and marked as such and shall be removed from the Site.
 - 2. Exposed surfaces that exhibit pitting, seam marks, roller marks, stains, discoloration, or other surface imperfections on the finished units shall be rejected.
- C. The Contractor shall verify dimensions, tolerances, and method of attachment with adjacent Work.
 - 1. Examine substrates, areas, and conditions where building signage will be installed for compliance with the requirements for installation, taking into account tolerances, and other conditions affecting performance of installed building signage.
 - a. Provide inserts, backing, blocking, anchoring devices, and reinforcements that must be built into other Work for the installation of building signage and appurtenances. Coordinate delivery with other Work to avoid delay.
 - 2. Notify the Engineer in writing of conditions detrimental to the proper and timely completion of the Work. Do not proceed with the Work until unsatisfactory conditions have been corrected in an acceptable manner.
 - 3. Commencement of the installation by the Contractor shall indicate Contractor's acceptance of the substrate, areas, and conditions.

3.05 PREPARATION

- A. Sequence installation properly with the installation and protection of other Work, so that neither will be damaged by the installation of the other.

SIGNAGE

3.06 INSTALLATION

- A. Installation shall comply with the requirements of the Contract Documents, with applicable references, with the requirements of the Code, NFPA 704, OSHA, and with Manufacturer's written instructions. Where a conflict occurs among these requirements, the more stringent shall apply, as directed by the Engineer.
- B. The Contractor shall provide corrosion resistant fasteners, anchors, and shims required for a complete installation, and shall be secure, plumb, level, straight, and true to line, allowing for required movement, including expansion and contraction.
- C. The Contractor shall provide separation of dissimilar materials to ensure no galvanic action occurs.
- D. Horizontal lines shall be level, and vertical lines shall be plumb.
- E. The Contractor shall block and reinforce walls as required to support building signage, and appurtenances.

3.07 CLEANING, FINISHING, AND PROTECTION

- A. Adhesive papers used for masking which become firmly bonded when exposed to heat and/or light shall not be used.
 - 1. Remove masking film and temporary labels as soon as possible after installation. Films and labels left in place after installation shall be the responsibility of the Contractor.
 - 2. Residue shall not be left on any surfaces.
- B. Upon completion of the installation, building signage and appurtenances shall be cleaned of dirt and other foreign matter to the satisfaction of the Engineer.
 - 1. Cleaning shall be performed again immediately prior to acceptance of the Work, when directed by the Engineer.
 - 2. Cleaning shall be performed in accordance with the Manufacturer's written instructions.
- C. Building signage shall be protected from damage from subsequent construction operations.
- D. The Contractor shall make adjustments required until accepted.
- E. The Contractor shall remove scratches and blemishes to the satisfaction of the Engineer.
- F. Damaged or defective items shall be removed and replaced at the direction of the Engineer.
- G. When building signage Work is completed, remove unused materials, containers, and equipment, and clean the Site of building signage debris.

3.08 RESTROOM SIGN SCHEDULE

Quantity	Sign Wording	Location
1	Restroom (with Men, Women, and Handicap symbols)	Door of Restroom in Pump Station

3.09 RESTRICTIVE/CAUTION SIGN SCHEDULE

Quantity	Sign Wording	Location
1 English	DANGER Equipment may start without warning	South wall of Pump Room
3 English	NOTICE No Smoking	On all exterior doors.
1 English	CAUTION Floor Loading Capacity 300 pounds per square foot (14.4 kPa) 3,000 pounds (13.3kN) concentrated	Posted in Pump Room.
1 English	2 TON BRIDGE CRANE	South wall of the Pump Room.
3 English	EXIT DO NOT BLOCK DOOR	Exterior of each exterior door.

3.10 BUILDING SIGN SCHEDULE

Quantity	Sign Wording	Location
1	Booster Pump Station	Exterior of South wall

END OF SECTION

SECTION 10 28 13 – TOILET ACCESSORIES

PART 1 -- GENERAL

1.01 SUMMARY

A. Section Includes:

1. Toilet accessories.

1.02 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

- A. Where reference is made to any of the below, the revision in effect at the time of bid opening shall apply.

B. Reference Specifications

01 33 00	Submittal Procedures
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C. Reference Standards

American National Standards Institute (ANSI)ing	
A117.1	Accessible and Useable Facilities
Americans with Disabilities Act (ADA)t	
ADAAG	Americans with Disabilities Accessibility Guidelines
Building Code	
	Refer to the Drawings to determine which building code applies within a given jurisdiction. The applicable building code, defined by the Drawings, is referenced herein as "the Code."

1.03 SUBMITTALS

1. Furnish submittals in accordance with Section 01 33 00 – Submittal Procedures.

1.04 ACTION SUBMITTALS

A. Product Data:

1. Manufacturer's specifications, technical data, installation methods, and maintenance instructions.

B. Certificates:

1. Certification by an independent testing organization demonstrating that grab bar strength and installation complies with the requirements indicated.
2. Certification of installer qualifications demonstrating compliance with the qualifications requirements indicated. Include a list of 5 similar completed projects with addresses of the project location, date of project completion, and contact information of the consultant firm of record, general contractor and owner.

C. Shop Drawings:

TOILET ACCESSORIES

1. Complete Shop Drawings showing location and detail of installation.

D. Samples:

1. When requested by the Engineer, submit samples of the materials proposed. Samples shall be clearly marked to show the Manufacturer's name, product identification, finish and color. New samples shall be resubmitted of each, as required, until approved by the Engineer. Upon approval, the Samples shall become the standard for acceptance for the project with regard to color, finish, and quality of each item. Approval of samples shall not relieve the Contractor from compliance with the Contract Documents.

1.05 CLOSEOUT SUBMITTALS

A. Warranty:

1. Submit a copy of the warranty.

1.06 QUALITY ASSURANCE

A. Single Source Responsibility:

1. Toilet and shower accessories shall be provided from a single Manufacturer.

B. Qualifications:

1. Installers:
 - a. A minimum of 5 years' experience in the successful completion of at least 5 projects of similar size and scope, employing similar products, materials, applications, and performance requirements.
 - b. Installers without these qualifications will not be accepted.

1.07 WARRANTY

A. Manufacturer Warranty:

1. Furnish the Manufacturer's written 10 year warranty for mirrors to cover silver spoilage. The term of the warranty shall begin on the date of Substantial Completion.

PART 2 -- PRODUCTS

2.01 TOILET ACCESSORIES

A. Manufacturer, or Equal:

1. Subject to the requirements indicated, provide products from one of the Manufacturers listed below, or Equal
 - a. Bobrick Washroom Equipment, Inc.
 - b. Bradley Corporation.
 - c. American Specialties, Inc.

TOILET ACCESSORIES

B. Description:

1. Accessories shall be satin finish stainless steel unless otherwise indicated.
2. Grab bars shall be provided with peened gripping surface.
3. Provide items complete with screws, bolts, and anchoring devices required for proper installation.
4. Provide units complete with anchorages, reinforcements, backing, and blocking for securing the toilet and shower accessories to other Work.

2.02 ACCESSORIES SCHEDULE

A. Refer to the Drawings for locations and quantities of item numbers indicated below:

Item Number	Description	Manufacturer Product / Model Number, or Equal
GB36	36-in Grab Bar	BOBRICK MODEL B-6806.99 X 36
GB42	42-in Grab Bar	BOBRICK MODEL B-6806.99 X 42
GBV	18-in Vertical Grab Bar	BOBRICK MODEL B-6806.99 X 18
SMTP	Surface Mounted Toilet Paper Dispenser	BOBRICK MODEL B-2888
PTWR	Surface Mounted Paper Towel Dispenser and Waste Receptacle	Bradley Corp Model 2028-11
SMSD	Surface Mounted Soap Dispenser	BOBRICK MODEL 818615
MS	Mirror, Channel Frame with Shelf (tempered glass)	BOBRICK MODEL B-1668 X 1836

2.03 FABRICATION

- A. The Contractor shall field verify size, location, and placement of toilet and shower accessories, shall advise the Engineer in writing of any necessary adjustments, and shall make the necessary adjustments prior to fabrication. The Contractor shall coordinate field measurements and shop drawings with fabrication and shop assembly to minimize field adjustments.

PART 3 -- EXECUTION

3.01 DELIVERY, STORAGE AND HANDLING

- A. Deliver materials to Site in Manufacturer's original, unopened packages, containers, or bundles with labels intact, which clearly identify contents.
- B. Store materials carefully in accordance with the Manufacturer's written instructions, in an area that is protected from deleterious elements, and in a manner that will prevent damage to the products.
- C. Handle materials in strict accordance with Manufacturer's written instructions.

3.02 INSPECTION

- A. The Contractor shall be totally responsible for the proper performance and completion of the Work under this Section.
- B. Systems and components shall be inspected before installation.
 - 1. Damaged or defective items shall be rejected and marked as such and shall be removed from the Site.
 - 2. Exposed surfaces that exhibit pitting, seam marks, roller marks, stains, discoloration, or other surface imperfections on the finished units shall be rejected.
- C. The Contractor shall verify dimensions, tolerances, and method of attachment with adjacent Work.
 - 1. Examine substrates, areas, and conditions where toilet and shower accessories and related items will be installed for compliance with requirements for installation, taking into account tolerances, and other conditions affecting performance of installed toilet and shower accessories.
 - a. Provide inserts, backing, blocking, anchoring devices, and reinforcements that must be built into other Work for the installation of toilet and shower accessories. Coordinate delivery with other Work to avoid delay.
 - 2. Notify the Engineer in writing of conditions detrimental to the proper and timely completion of the Work. Do not proceed with the Work until unsatisfactory conditions have been corrected in an acceptable manner.
 - 3. Commencement of the installation by the Contractor shall indicate Contractor's acceptance of the substrate, areas, and conditions.

3.03 INSTALLATION

- A. Installation shall comply with the requirements of the Contract Documents, with the requirements of The Code, ADAAG, and ANSI A 117.1 with applicable referenced standards, and with Manufacturer's written instructions. Where a conflict occurs among these requirements, the more stringent shall apply, as directed by the Engineer.
- B. Sequence installation properly with the installation and protection of other Work, so that neither will be damaged by the installation of the other.
- C. The Contractor shall provide corrosion resistant fasteners, anchors, and shims required for a complete installation, and shall be secure, plumb, level, straight, and true to line, allowing for required movement, including expansion and contraction.
 - 1. Use fasteners appropriate to substrate as recommended in writing by the Manufacturer. Unless otherwise indicated, provide tamper-proof, theft-resistant, concealed mounting devices and fasteners, as recommended in writing by Manufacturer.
 - 2. Install units in locations and at heights indicated.

- a. Where heights and locations are not indicated, such items shall be installed where directed by the Engineer.
- 3. Coordinate location of concealed supplemental blocking, backing, and additional anchoring reinforcement with items to be installed herein.
- D. The Contractor shall provide separation of dissimilar materials to ensure no galvanic action occurs.

3.04 CLEANING, FINISHING, AND PROTECTION

- A. Adhesive papers used for masking, which become firmly bonded when exposed to heat and/or light shall not be used.
 - 1. Remove masking film and temporary labels as soon as possible after installation. Film and labels left in place after installation shall be the responsibility of the Contractor.
 - 2. Residue shall not be left on any surfaces.
- B. Upon completion of the installation, toilet and shower accessories and appurtenances shall be cleaned of all dirt and other foreign matter to the satisfaction of the Engineer.
 - 1. Cleaning shall be performed again immediately prior to acceptance of the Work, when directed by the Engineer.
 - 2. Cleaning shall be performed in accordance with the Manufacturer's written instructions.
- C. Toilet and shower accessories shall be protected from damage from subsequent construction operations.
- D. The Contractor shall remove scratches and blemishes to the satisfaction of Engineer.
- E. Damaged or defective items shall be removed and replaced at the direction of the Engineer.
- F. When toilet and shower accessories Work is completed, remove unused materials, containers, and equipment, and clean the Site of toilet and shower accessories debris.

END OF SECTION

SECTION 10 44 00 – FIRE PROTECTION SPECIALTIES

PART 1 -- GENERAL

1.01 SUMMARY

A. Section Includes:

1. Fire extinguishers

1.02 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

A. Where reference is made to any of the below, the revision in effect at the time of bid opening shall apply.

B. Reference Specifications

01 33 00	Submittal Procedures
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C. Reference Standards

Building Code	
	Refer to the Drawings to determine which building code applies. The applicable building code, defined by the Drawings, is referenced herein as "the Code".
National Fire Protection Association publications (NFPA)	
NFPA 10	Standard for Portable Fire Extinguishers
Underwriter's Laboratories (UL)	

1.03 SUBMITTALS

A. Furnish submittals in accordance with Section 01 33 00 – Submittal Procedures.

1.04 ACTION SUBMITTALS

A. Product Data:

1. Manufacturer's specifications, technical data, installation methods, and maintenance instructions.

B. Certificates:

1. UL certification for each fire extinguisher unit provided.
2. Certification of Manufacturer qualifications demonstrating compliance with the qualifications requirements indicated.
3. When requested by the Engineer, furnish other certifications as may be required to show compliance with the Contract Documents.

C. Shop Drawings:

1. Complete Shop Drawings showing location and detail of installation.

2. Shop Drawings shall include mounting and bracket details.

1.05 QUALITY ASSURANCE

A. Single Source Responsibility:

1. Fire extinguishers shall be provided by a single Manufacturer.

B. Qualifications:

1. Manufacturers:

- a. Fire extinguisher Manufacturer shall have a minimum of 20 years of fire extinguisher manufacturing experience.
- b. Manufacturers without these qualifications will not be accepted.

PART 2 -- PRODUCTS

2.01 GENERAL

- A. Fire extinguishers, accessories, and installation shall comply with the Code, NFPA 10, and with the Manufacturer's published recommendations and specifications.

2.02 FIRE EXTINGUISHERS

A. Manufacturer, or Equal:

1. Subject to the requirements indicated, provide products from one of the Manufacturers listed below, or Equal.
 - a. J.L Industries, Inc.
 - b. Larsen's Manufacturing Co.
 - c. General Fire Extinguisher Co.

B. Description:

1. Fire extinguishers in every location, except in rooms or spaces containing electrical switchgear, motor control centers, variable frequency drives, generator rooms, etc., shall be 20 lb capacity, 6A:120BC (ABC), UL-rated, chemical multipurpose type.
2. Fire extinguishers in rooms or spaces containing electrical switchgear, motor control centers, variable frequency drives, generator rooms, etc., shall be 20 lb capacity 10 BC, UL-rated, carbon dioxide type.
3. Fire extinguishers shall be provided with severe duty corrosion resistant finish, red enamel steel cylinders.
4. Fire extinguishers shall be provided with mounting brackets, which support the bottom and sides of extinguishers, and are specially designed for the extinguisher, as recommended in writing by the Manufacturer.

PART 3 -- EXECUTION

3.01 DELIVERY, STORAGE, AND HANDLING

- A. Deliver materials to Site in Manufacturer's original, unopened packages, containers, or bundles with labels intact, which clearly identify contents.
- B. Store materials carefully in accordance with the Manufacturer's written instructions, in an area that is protected from deleterious elements, and in a manner that will prevent damage to the products.
- C. Handle materials in strict accordance with Manufacturer's written instructions.

3.02 LOCATIONS

- A. The Contractor shall verify the fire extinguisher locations and mounting heights on the Contract Drawings with the Fire Marshal before installation. If locations on the Drawings are not accepted by the Fire Marshal, install fire extinguishers where directed by the Engineer.

3.03 PROJECT CONDITIONS

- A. Comply with Manufacturer's written instructions for environmental conditions before, during, and after installation.
- B. Protect surrounding Work from damage that may result from operations under this Section.

3.04 INSPECTION

- A. The Contractor shall be totally responsible for the proper performance and completion of the Work under this Section.
- B. Systems and components shall be inspected before installation.
 - 1. Damaged or defective items shall be rejected and marked as such and shall be removed from the Site.
 - 2. Exposed surfaces that exhibit pitting, seam marks, roller marks, stains, discoloration, or other surface imperfections on the finished units shall be rejected.
- C. The Contractor shall verify dimensions, tolerances, and method of attachment with adjacent Work.
 - 1. Examine substrates, areas, and conditions where fire extinguishers and appurtenances will be installed for compliance with the requirements for installation, taking into account tolerances, and other conditions affecting performance of installed fire extinguishers and appurtenances.
 - a. Provide inserts, backing, blocking, anchoring devices, and reinforcements that must be built into other Work for the installation of fire extinguishers and appurtenances. Coordinate delivery with other Work to avoid delay.

2. Notify the Engineer in writing of conditions detrimental to the proper and timely completion of the Work. Do not proceed with the Work until unsatisfactory conditions have been corrected in an acceptable manner.
3. Commencement of the installation by the Contractor shall indicate Contractor's acceptance of the substrate, areas, and conditions.

3.05 PREPARATION

- A. Sequence installation properly with the installation and protection of other Work, so that neither will be damaged by the installation of the other.

3.06 INSTALLATION

- A. Installation shall comply with the requirements of the Contract Documents, with applicable references, the requirements of the Code, with NFPA 10, and with Manufacturer's written instructions. Where a conflict occurs among these requirements, the more stringent shall apply, as directed by the Engineer.
- B. The Contractor shall block and reinforce walls as required to support the fire extinguishers and appurtenances.
- C. The Contractor shall provide corrosion resistant fasteners, anchors, and shims required for a complete installation, and shall be secure, plumb, level, straight, and true to line, allowing for required movement, including expansion and contraction.
- D. The Contractor shall provide separation of dissimilar materials to ensure no galvanic action occurs.
- E. Horizontal lines shall be level, and vertical lines shall be plumb.
- F. Secure mounting brackets and fire extinguishers to structure, square and plumb.

3.07 CLEANING, FINISHING, AND PROTECTION

- A. Adhesive papers used for masking which become firmly bonded when exposed to heat and/or light shall not be used.
 1. Remove masking film and temporary labels as soon as possible after installation. Films and labels left in place after installation shall be the responsibility of the Contractor.
 2. Residue shall not be left on any surfaces.
- B. Upon completion of the installation, fire extinguishers and appurtenances shall be cleaned of dirt and other foreign matter to the satisfaction of the Engineer.
 1. Cleaning shall be performed again immediately prior to acceptance of the Work, when directed by the Engineer.
 2. Cleaning shall be performed in accordance with the Manufacturer's written instructions.
- C. Fire extinguishers shall be protected from damage from subsequent construction operations.

- D. The Contractor shall make adjustments required until accepted.
- E. The Contractor shall remove scratches and blemishes to the satisfaction of the Engineer.
- F. Damaged or defective items shall be removed and replaced at the direction of the Engineer.
- G. When fire extinguishers Work is completed, remove unused materials, containers, and equipment, and clean the Site of fire extinguishers debris.
- H. Fire extinguishers shall be inspected and certified within 30 days of Substantial Completion.

END OF SECTION

SECTION 13 34 19 - PRE-ENGINEERED METAL BUILDINGS

PART 1 -- GENERAL

1.1 THE SUMMARY

- A. The Contractor shall provide pre-engineered metal building(s), low-rise, one or two story, including second floor framing system and composite metal decking, as applicable, and appurtenant WORK, complete and in place, with operational components, in accordance with the Contract Documents.
- B. The Manufacturer shall furnish professional design and engineering services as required for pre-engineered metal building(s) and appurtenances as indicated herein.
- C. The Contractor shall coordinate color samples with other Sections through the submittal process.

1.2 REFERENCE SPECIFICATIONS, CODES AND STANDARDS

A. Reference Specifications

01 33 17	Structural Design, Support and Anchorage
05 30 00	Metal Decking
08 11 13	Steel Doors and Frames
08 23 33	Overhead Coiling Doors
08 71 00	Door Hardware
08 91 00	Louvers
09 96 00	High Performance Coatings

- B. The edition of the standards applicable to the Work shall be those editions referenced by the 2024 Ohio Building Code (OBC). If the standard is not referenced by the OBC, not an OBC-referenced standard listed below, the edition of the standard applicable to the Work shall be the edition in effect on the date of signing and sealing of the contract specifications.

American Institute of Steel Construction (AISC)	
AISC 360	Specification for Structural Steel Buildings
AISC	Steel Construction Manual
American Iron and Steel Institute (AISI)	
AISI S100	North American Specification for the Design of Cold-Formed Steel Structural Members
American Society for Testing and Materials (ASTM)	
ASTM A36	Standard Specification for Carbon Structural Steel
ASTM A123	Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
ASTM A153	Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware

ASTM A307	Standard Specification for Carbon Steel Bolts, Studs, and Threaded Rod 60 000 PSI Tensile Strength
ASTM A529	Standard Specification for High-Strength Carbon-Manganese Steel of Structural Quality
ASTM A572	Standard Specification for High-Strength Low-Alloy Columbium-Vanadium Structural Steel
ASTM A653	Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process
ASTM A992	Standard Specification for Structural Steel Shapes
ASTM A1008	Standard Specification for Steel, Sheet, Cold-Rolled, Carbon, Structural, High-Strength Low-Alloy, High-Strength Low-Alloy with Improved Formability, Required Hardness, Solution Hardened, and Bake Hardenable
ASTM A1011	Standard Specification for Steel, Sheet and Strip, Hot-Rolled, Carbon, Structural, High-Strength Low Alloy, High-Strength Low-Alloy with Improved Formability, and Ultra-High Strength
ASTM F1554	Standard Specification for Anchor Bolts, Steel, 36, 55, and 105-ksi Yield Strength
ASTM F3125	Standard Specification for High Strength Structural Bolts and Assemblies, Steel and Alloy Steel, Heat Treated, Inch Dimensions 120 ksi and 150 ksi Minimum Tensile Strength, and Metric Dimensions 830 MPa and 1040 MPa Minimum Tensile Strength
American Welding Society (AWS)	
AWS D1.1	Structural Welding Code-Steel
AWS D1.3	Structural Welding Code - Sheet Steel
Factory Mutual Global (FM)	
FM Standard 4471	Approval Standard for Class 1 Roofs for Hail Damage Resistance, Combustibility, and Wind Uplift Resistance
International Code Council (ICC)	
IBC	2021 International Building Code
Metal Building Manufacturer's Association (MBMA)	
	Metal Building Systems Manual
The Society for Protective Coatings (SSPC)	
SSPC-SP2	Hand Tool Cleaning
SSPC-SP8	Pickling
Underwriters Laboratories (UL)	
UL 580	Standard for Tests for Uplift Resistance of Roof Assemblies
UL 723	Standard for Test for Surface Burning Characteristics of Building Materials

C. Building Code: The 2024 Ohio Building Code is the applicable building code and is referenced herein as "the CODE."

1.3 CONTRACTOR SUBMITTALS

A. Furnish submittals in accordance with the Contract Documents.

- B. Literature: Manufacturer's specifications, technical data, installation methods, and maintenance instructions, and the following:
 - 1. Complete operation instructions for operable components.
 - 2. Manufacturer's full-range color charts, indicating custom color availability for color selection by the Owner.
 - 3. Additional information for the building system, roof panels, wall panels, accessories and components.
- C. Warranty: Submit a copy of the warranty.
- D. Certifications
 - 1. Certification of compliance with the Structural Requirements of paragraph 2.1.A.
 - 2. Certification of manufacturer qualifications demonstrating compliance with the qualifications requirements indicated. Include a list of 5 similar completed projects with addresses of the project location, date of project completion, manufacturer's products, and contact information of the consultant firm of record, general contractor and owner.
 - 3. Certification of installer qualifications demonstrating compliance with the qualifications requirements indicated. Include a list of 5 similar completed projects with addresses of the project location, date of project completion, and contact information of the consultant firm of record, general contractor and owner.
 - 4. Certification from the manufacturer stating that galvanizing has been completed in accordance with these specifications.
 - 5. Certification of welder qualifications in accordance with the AWS requirements.
 - 6. Submit certification verifying that the metal roof system has been tested and approved by FM Standard 4471 for Class 1.
 - 7. Submit certification verifying that the metal roof system has been tested and approved by UL 580 as Class 90.
 - 8. When requested by the Engineer, furnish other certifications as may be required to demonstrate compliance with the Contract Documents.
- E. Design Drawings and Design Calculations: Complete Shop Drawings showing location and details of installation, and design calculations.
 - 1. Design Drawings and Design Calculations shall be prepared, signed, and stamped by a licensed professional civil or structural engineer registered in the State of Ohio.
 - 2. Design Drawings shall be drawn to sufficient scale, showing fully-dimensioned layout, including plans, sections, elevations and details of construction, connections to the foundation, joints, penetration details, preformed metal closures, flashing, gutters, and downspouts, fastenings, system caulking, sealants, gaskets, appurtenances, locations of framed openings, special project specific conditions, location of custom-cut panels, provisions for expansion and contraction, doors, windows, louvers, connections, accessories, and trim.

- a. Design Drawings shall include material descriptions, finish, color, details of construction, installation, and accessories of each pre-engineered metal building and shall include, as a minimum:
 - 1) Erection drawings with written procedures to clearly explain proper installation of fasteners, trim, gaskets, and sealants. Erection drawings shall also include a notation requiring the installer to coordinate with other trades.
 - 2) Transverse cross sections.
 - 3) Roof plans showing sizes and locations of structural panels and connections.
 - 4) Elevations of walls showing sizes and locations of structural panels and connections, openings for doors, removable wall panels, HVAC and other mechanical and electrical equipment.
 - 5) Details of door, door frames, and other openings and accessories.
 - 6) Design and detail penetrations, including hot pipe penetrations, to be weathertight. Coordinate locations of penetrations.
 - 7) Manufacturer's standard details may be used in addition to the shop drawings listed above provided that the portions that apply are clearly marked and those parts that do not apply are clearly marked.
 - 8) Foundation drawings.
 - a) Foundation plan with base plate details including anchor bolt plan. A diagram shall be included showing the vertical and lateral loads applied on the foundation for each load combination.
 - 9) Second floor / Mezzanine drawings.
 - a) Second floor and Mezzanine drawings provided with framing and connection details.
3. Design Calculations
 - a. Design calculations shall include a complete stress and deflection analysis of all structural components and connections, including the elevated floor framing system(s), including interior columns, where applicable.
 - b. Design calculations shall include supporting information for the structural roof deck with ICC-ES/IAPMO approval substantiating the capacity of the deck to act as a roof diaphragm and provide lateral support for out-of-plane loading.
 - c. Design calculations shall substantiate a complete load path for the wind and seismic lateral force resisting system including design of drag, collector and bracing elements (including connections) required to transfer loading, including overstrength factors, to the foundation.
4. Specifications for the painting system including paint manufacturer's name, product trade name, and preparation for shop and field coats.

- F. Deferred Approval: The shop drawings and design calculations shall be submitted to the Building Official(s) having jurisdiction for review and approval prior to construction. The Contractor shall provide all engineering support as necessary during the review process with all Building Official(s) having jurisdiction, including providing responses to review comments, attendance at meetings, and submitting all requested documentation.
- G. Samples: The Contractor shall submit 2 samples of each of the following. Unless otherwise indicated, samples shall be full size and shall show gauges, configuration, construction, finish and color proposed for the various components. Samples shall be clearly marked to show the manufacturer's name, product identification, finish and color. New samples shall be resubmitted of each, as required, until approved by the Engineer. Upon approval, the samples shall become the standard for acceptance for the project with regard to color, finish, and quality of each item. Approval of samples shall not relieve the Contractor from compliance with the Contract Documents.

- 1. Metal Wall and Roof Panels

- a. Assembled half panels, with representative panel support framing, showing seam, and appurtenances; one-foot long, in color and finish indicated.
 - b. Three-inches (76 mm) by 4-inch (102 mm) color samples showing substrate, finish, and color.

1.4 QUALITY ASSURANCE

- A. Single Source Responsibility: Pre-engineered metal buildings and components shall be provided by a single manufacturer.

- B. Manufacturer Qualifications

- 1. Pre-engineered metal building manufacturer shall be a current member of the Metal Building Manufacturer's Association (MBMA).
 - 2. Pre-engineered metal building manufacturer shall have a minimum of 20 years of Pre-engineered metal building manufacturing experience.
 - 3. Pre-engineered metal building manufacturer shall have a minimum of 5 similar successful projects over the most recent 10 years, employing similar products, materials, applications, and performance requirements.
 - 4. Manufacturers without these qualifications will not be accepted.

- C. Installer Qualifications

- 1. Installer shall have a minimum of 5 years' experience in the successful completion of at least 5 projects of similar size and scope, employing similar products, materials, applications, and performance requirements.
 - 2. Installer shall be trained, certified, and authorized by the manufacturer to install the manufacturer's product.
 - 3. Installers without these qualifications will not be accepted.

1.5 SPECIAL WARRANTY PROVISIONS

- A. For pre-engineered metal building(s) and appurtenances furnish manufacturer's 1-year written warranty to cover defects in materials, products, and manufacturing workmanship.
- B. Installation Warranty: At the time of Substantial Completion, the manufacturer shall warrant that the installation is not defective in and conforms to the manufacturer's erection drawings, except for reasonable variances not impairing the usefulness thereof.
- C. Finish Warranty: The manufacturer shall warrant against spalling, fading, chalking, peeling, cracking, checking, chipping, or erosion to base metal of the exterior panel finish, for a period of 20 years from the date of Substantial Completion. The finish shall not change color more than eight NBS units for a period of 20 years from the date of Substantial Completion.
- D. Weathertight Warranty: Manufacturer shall provide a weathertight warranty against water penetration of the pre-engineered metal building system, including panel joints and trim conditions for a period of 20 years from date of Substantial Completion.
- E. In the event that the pre-engineered metal building fails to meet the warranty standards above, the manufacturer shall, at the manufacturer's sole cost (including labor and materials), replace or repair the pre-engineered metal building, as agreeable to the Owner throughout the term of the warranty.
- F. The Contractor shall furnish separate, but concurrently running, 5-year written warranty to cover installation and associated labor.
- G. The term of the warranties shall begin on the date of Substantial Completion, unless otherwise indicated.

PART 2 -- PRODUCTS

2.1 GENERAL

- A. Structural Requirements
 - 1. Pre-engineered metal building(s), including structural framing, accessories, related assemblies, components, appurtenances and attachment details shall comply with the CODE and shall be designed and installed for resistance to the structural design criteria indicated in the Contract Documents in accordance with the CODE. Where a conflict occurs between the requirements of this Section and the CODE, the more stringent shall apply.
 - a. Refer to Section 01 33 17 – Structural Design, Support and Anchorage for additional design criteria.
 - 2. The Manufacturer shall provide additional non-standard bracing, reinforcements, anchors, and heavier gauge materials in order to conform to the structural design criteria indicated and to other performance requirements indicated.
 - 3. Pre-engineered metal building(s) including related assemblies, components, and accessories shall be manufactured and installed to maintain the specified performance requirements, under the structural design criteria indicated, without defects, damage, or failure.

B. Thermal Movements: Pre-engineered metal building(s) and accessories shall be designed to provide for such expansion and contraction of component materials as will be caused by temperature changes without causing buckling, stresses or other cladding components, failure of joints, undue stress on structural elements, damaging loads on fasteners, reduction of performance, or other visual or technical detrimental effects.

C. Manufacturer and Product, or Equal

1. Subject to the requirements indicated, provide manufacturer and product listed below, or equal.
 - a. Butler Manufacturing Company - With additional options and custom features as specified herein.
 - b. Star Building Systems - With additional options and custom features as specified herein.
 - c. Nucor Building Systems - With additional options and custom features as specified herein.

D. Description

1. Pre-engineered metal building(s) shall be provided complete, and shall include the structural framing, connections, base plates including bolt patterns, framed openings for wall and penetrations, and framed openings for doors, windows and louvers; metal roofing and scrim faced insulation with metal wall panel system, gutters and downspouts, pipe flashing, gable trim, flashing, closures, fasteners, sealants, and all other component parts for a complete weathertight, exterior envelope. Building shall be fully insulated in walls and roof.
 - a. Dimensions: The dimensions shall be as indicated on the Contract Documents. The minimum clear height to the underside of the roof members at their lowest point (eave height) shall be as indicated on the Contract Documents. The roof slope shall be a minimum of ½ inch per foot and meet code requirements.
 - b. Structural System
 - 1) The building's structural system shall be a clear span rigid frame system as determined by the manufacturer and in coordination with the Contract Documents.
 - 2) The building's structural system shall be selected such that it is compatible with the foundation system shown on the Contract Documents.

2.2 MATERIALS

A. Metals

1. Members fabricated from plate or bar stock: provide 42,000-psi minimum yield strength and comply with the requirements of ASTM A529, A1011, or A572.
2. Members fabricated by cold forming: ASTM A1008, Grade 50
3. Galvanized Steel Sheet: ASTM A653 with G90 coating

4. Bolts for Structural Framing: ASTM F3125
5. Anchors into concrete: ASTM F1554 Grade 36 minimum
6. Hot rolled structural shapes: ASTM A36, A992, or A1011
7. Square and rectangular hollow structural sections (HSS): ASTM A500 Grade B minimum

2.3 DESIGN CRITERIA

A. Design Loads

1. Roof and floor Live load, Wind load, and Seismic load shall be per the design criteria listed on the Structural general notes drawings and Structure specific drawings.
2. Collateral loads shall include dead and live loads resulting from HVAC, piping, and other items suspended from the roof. This loading shall be coordinated with the drawings of all disciplines and manufacturer's shop drawings.
3. Crane loads shall be as required by the crane manufacturer for the crane capacity and type indicated on the Contract Documents, including impact and runway horizontal forces.

B. Design Requirements

1. Design structural panels and exterior covering materials for applicable loads and combinations of loads in accordance with the MBMA Metal Building Design Manual.
2. For design of structural panels, comply with the requirements of the AISC.
3. For design of light gage steel members, comply with AISI for design requirements and allowable stresses.
4. Welded connections shall comply with AWS.
5. Design framing to withstand stresses resulting from combinations of loads that produce the maximum allowable stresses in that member as prescribed in MBMA's Metal Building Design Manual.
6. The building shall be designed to withstand all loading conditions both with and without wall panels in place.

2.4 FOUNDATION AND FLOOR SLAB(S)

- A. The foundation and first floor slab shall be reinforced concrete and elevated floor slab(s) shall be composite metal deck conforming to the requirements of the CODE and shall be provided by the Contractor.
- B. The pre-engineered metal building manufacturer shall specify the service level reactions not to be exceeded for the pre-engineered metal building base plate connections to the foundation to the Engineer.

- C. The pre-engineered metal building manufacturer shall coordinate with the Engineer to make any base plate revisions based on final anchorage design. The Contractor shall coordinate the anchorage and base plate details with the foundation and pre-engineered metal building engineer.
- D. The Contractor shall coordinate the details of anchorages of the pre-engineered metal building to its foundation. The Contractor shall provide the anchor bolts and layout templates and allow for any foundation revisions necessary to adapt or support the pre-engineered metal building during construction as accepted by the Engineer.

2.5 STRUCTURAL FRAMING

A. Manufacturer and Product, or Equal

- 1. Subject to the requirements indicated, provide manufacturer and product listed below, or equal.
 - a. Butler Manufacturing Company
 - b. Star Building Systems
 - c. Nucor Building Systems

B. Description

- 1. Design of the structural system for the pre-engineered metal building shall be clear span rigid frame with tapered columns, tapered roof beams, and gable roof.
- 2. Primary Structural Members
 - a. Rigid Frames
 - 1) Frames shall consist of welded plate section columns and roof beams complete with necessary splice plates for bolted field assembly.
 - 2) Welding shall be performed in accordance with the American Welding Society Code for Building Construction.
 - 3) All base plates, cap plates, compression plates, and stiffener plates shall be factory-welded into place and have the connection holes shop fabricated.
 - 4) All splice plates shall be shop fabricated complete with bolt connection holes.
 - 5) Columns and roof beams shall be fabricated complete with holes in webs and flanges for the attachment of secondary structural members and bracing.
 - b. All bolts for field assembly of frame members shall be high strength bolts as indicated on erection drawings.
 - c. Endwall Structurals
 - 1) Endwall frames shall consist of endwall corner posts, endwall roof beams, and endwall posts as required by design criteria.

- a) All splice plates and connection clips shall be shop fabricated complete with bolt connection holes.
 - b) Beams and posts shall be shop fabricated complete with holes for the attachment of secondary structural members.
- d. Elevated Floor Systems
 - 1) Frames shall consist of welded plate section columns, floor beams and joists complete with necessary splice plates for bolted field assembly.
 - 2) Welding shall be performed in accordance with the American Welding Society Code for Building Construction.
 - 3) All base plates, cap plates, compression plates, and stiffener plates shall be factory-welded into place and have the connection holes shop fabricated.
 - 4) All splice plates shall be shop fabricated complete with bolt connection holes.
 - 5) Columns and floor beams shall be fabricated complete with holes in webs and flanges for the attachment of secondary structural members and bracing.
- 3. Secondary Structural Members
 - a. Purlins and Girts
 - 1) Purlins and girts shall be minimum 8-inch (203 mm) or 9-1/2-inch (241 mm) deep "Z" sections, precision roll formed.
 - 2) Outer flange of all purlins and girts shall contain factory-punched holes for panel connections.
 - b. Eave Struts
 - 1) Eave struts shall be minimum 8-inch (203 mm) or 9-1/2-inch (241 mm) in deep "C" sections.
 - 2) Outer flange of all eave struts shall contain factory-punched holes for panel connections.
 - c. Bracing
 - 1) Diagonal bracing shall be designed by the building manufacturer and attached to columns and roof beams.
 - 2) Flange braces, sag angles, etc., when required, shall be supplied by the building manufacturer.
 - 3) All bracing locations shall be coordinated with ductwork, piping, door openings, and ventilation openings.
 - d. Secondary Framing

- 1) Provide framing for wall openings where windows, doors, ventilation equipment, and removable wall panels occur shall be stiffened flange channels and shall be provided by the prefabricated metal building manufacturer.
- 2) Base channel shall not be less than 14-gauge shop painted cold-formed sections.

4. Structural Galvanizing

- a. Structural steel framing shall be hot dip galvanized meeting the requirements of ASTM A653, with a minimum G90 thickness. Steel shall be galvanized prior to erection.

2.6 METAL ROOF PANELS

A. Manufacturer and Product, or Equal

1. Subject to the requirements indicated, provide manufacturer and product listed below, or equal.
 - a. Butler Manufacturing Company; CMR-24
 - b. Star Building Systems; LS-36
 - c. Nucor Building Systems; AWI "SR2"

B. Description

1. Panels shall be roll formed to provide a width coverage of 24-inches (610 mm) to 36-inches (915 mm).
 - a. There shall be two major corrugations, 2-inches high (51 mm), spaced 24-inches (610 mm) on center.
 - b. There shall be minor corrugations, spaced 6-inches (152 mm) on center between and perpendicular to the major corrugations.
2. The panel endlaps shall be 6-inches (152 mm).
 - a. Panels shall be of maximum length so as to minimize panel endlaps.
 - b. Endlaps shall be engineered to occur over and be fastened to a secondary structural member.
 - c. The upper end of all panels shall be marked for the proper location of endlap sealant.
3. Ridge assembly shall be designed to allow for expansion and contraction.
4. Eave panels shall extend beyond the building structural line.
5. Panels shall be factory pre-punched at panel ends to match pre-punched holes in the eave structural members. Panel end splices shall be factory pre-punched and pre-notched. Panel end splices shall allow for expansion and contraction of the panels.

6. Panel Material

- a. Panel material shall be 24-gauge galvanized steel (80,000 psi yield) G90 coating conforming to ASTM Galvanized Specification A653.

7. Insulation Board

- a. Insulation board shall be rigid glass-fiber reinforced, polyisocyanurate foam plastic core.
- b. The insulation board shall provide Class A fire rating and be approved for use without a thermal barrier. Board insulation shall have a flame spread of 25 or less in compliance with Class I Factory Mutual Approval and UL Fire Hazard Classification Ratings UL 723.
- c. Maximum thickness for insulation board shall be 4-inches (102 mm). Insulation board shall be covered with aluminum facing with a perm rating of 0.03 in compliance with Water Vapor Perm per ASTM E 96.
- d. Thermal performance shall be in accordance with ASTM C 1363 and test U-factors for composite roof section.

8. Vapor Retarder

- a. Vapor retarder shall be a white polypropylene, UV-stabilized, with minimum thickness of 0.0015-inch and laminated to 30-pound Kraft paper. Vapor retarder shall be reinforced with glass fiber and polyester scrim and provide a perm rating of 0.02 in accordance with ASTM E 96. Vapor retarder shall have a Flame Spread of 5 and Smoke Development of 30.

9. Interior Liner Panels

- a. Interior Liner Panels shall be formed from 0.0149-inch minimum total coated steel with 80,000 psi minimum yield strength.
- b. Panel finish shall be hot dip galvanized meeting the requirements of ASTM A653, with a minimum G90 thickness. Steel shall be galvanized prior to erection.
- c. Panel dimensions are 36-inches wide with ½-inch high corrugations, 3-inches on center.
- d. Lengths shall be factory cut as required.

10. Roof Assembly

- a. Roof Assembly shall be composed of the metal roof panels, insulation board, vapor retarder, and interior liner panel to provide an R-value of 30.0 minimum.

2.7 METAL WALL PANELS

A. Manufacturer and Product, or Equal

- 1. Subject to the requirements indicated provide manufacturer and product listed below, or equal.

- a. Butler Manufacturing Company; StylWall II Panels
- b. Star Building Systems; Designer Series
- c. Nucor Building Systems

B. Description

- 1. Panels shall be nominally 2-inch deep and 16-inches (406 mm) wide with 4-inch wide flutes.
- 2. Panels shall be one piece from base to building eave.
- 3. The upper end of panels shall be cut to match roof panels and slopes.
- 4. The bottom end of the panels shall be straight on.
- 5. Wall panel ends shall be factory pre-punched and shall match pre-punched holes in structural steel.
- 6. Panel material shall be ASTM A653, Grade C, 24 gauge steel with zinc coating (designated G90) conforming to ASTM A653.
- 7. Fasteners shall be concealed.
- 8. Interior liner panel
 - a. Panel shall be nominal 42-inch (1,145 mm) wide with major corrugations 1/16-inch (1.6 mm) deep, 6-inch (161 mm) on center.
 - b. Panel shall be formed from 24 gauge steel with minimum yield strength of 80,000 psi.
 - c. Panels finish shall be G60 galvanized steel (per ASTM A525) and 0.60 mil (minimum) stone white polyester paint on exposed side unless otherwise noted in Contract Documents, and 0.30 mil (minimum) wash coat paint (color may vary) on unexposed side.
 - d. Panels shall extend vertically from floor to underside of roof and provide a complete interior sheathing at exterior walls.
- 9. Provide fiberglass batt insulation (R-21) with vapor retarder membrane..

2.8 METAL WALL AND ROOF PANEL FINISH AND COLOR

- A. Finish: Exterior panel surface shall be **Butler-Cote 500 FP** (70% Kynar 500 fluoropolymer), or equal.
 - 1. Interior surface finish shall be manufacturer's standard polyester paint finish on reverse face.
- B. Color shall be selected and approved by the Owner from manufacturer's full color range including custom colors, and may be required to match other building components, as determined by the Owner.

1. Color selection: Color shall match colors indicated below, as selected and approved by the Owner.

Metal Roof Panels	
Exterior:	Bright Silver Metallic
Interior:	White
Metal Wall Panels	
Exterior:	Bright Silver Metallic
Interior:	White

2. The Owner reserves the option of changing this color selection during the submittal process.
3. Color shall be uniform with no variation in shade, and panels of different color batches will not be acceptable.

2.9 BUILDING ACCESSORIES

A. Accessories

1. Accessories shall be manufacturer's standard unless otherwise indicated. Location of standard accessories shall be indicated on the erection drawings.
 - a. All miscellaneous trim and accessories shall match adjacent panels.
 - b. Metal curbs and pipe flashing shall be manufacturer standard except that interior faces of curbs must be fully enclosed also.
 - c. Skylights shall be insulated lite panels as compatible with CMR-24 roof panel systems.
 - 1) Lite panels shall be translucent cool white, fiberglass reinforced, insulated, plastic panel. The panel shall provide diffused natural light and maintain a weathertight roof system.
 - 2) Provide number of skylights in locations as shown on the drawings.
 - 3) Panels shall be nominal 2-feet 0 inches (61 cm) wide by 6-foot 0 inches (3.2 m) long.
 - 4) Load capacity shall equal or exceed that of roof panels.
 - 5) Interior and exterior faces of insulated panel shall be factory assembled and sealed, forming a 1-inch (25 mm) dead air space.
 - d. Gutters, downspouts, and trim pieces shall be provided by the manufacturer.
 - e. Trim materials shall be:
 - 1) Outside corner trim shall be of the same material and finish as the exterior of wall panel.

- 2) Gutters, downspouts, eave trim and gable trim shall be prepainted galvanized steel. Color shall match adjacent wall color.
 - 3) Door side trim, drip gutters and base trim shall be prepainted Butler-Tone slate black galvanized steel.
- f. For doors and frames refer to Section 08 11 13 – Steel Doors and Frames.
 - g. For overhead doors refer to Section 08 23 33 – Overhead Coiling Doors.
 - h. For door hardware refer to Section 08 71 00 - Door Hardware.
 - i. For louvers refer to Section 08 91 00 - Louvers.

B. Roof Fasteners

1. Insulation, bearing plates, and panel clips shall be fastened to structural members with fasteners as per manufacturer's erection drawings, using factory pre-punched holes in structural members.
2. All connections of panels to structural members except at eave shall be by clips with moveable tabs that are seamed into the standing seam sidelap.
3. Panel clips shall be fastened to structural members with fasteners as per manufacturer's erection drawing, using factory pre-punched holes in structural members.

C. Wall Fasteners

1. Shadowrib wall panel-to-structural connections shall be made with Scrubolts or self-drilling screws. Panel-to-panel connections shall be made with self-drilling screws.
2. Fastener locations shall be as shown on erection drawings.
3. All exposed fasteners shall be prepainted to match wall color.

D. Sealants

1. Factory applied side lap sealant shall be a one part, non-skinning, non-drying, synthetic butyl elastomer.
2. Field applied hidden sealant at side laps, end laps, and flashing details shall be gun grade non-skinning butyl elastomer or polymeric non-skinning butyl tape to ensure weather tightness.
3. Exposed sealant shall be as one-part moisture curing, gun grade polyurethane as recommended in writing by the Manufacturer. Color shall match adjacent panels as approved by Owner. Provide custom color as required.

E. Flashing

1. Preformed metal closures, trim pieces, flashings, sheets, clips, and associated appurtenances shall be as indicated or as otherwise required for weather tightness or completeness, and shall be of the same material, color, and finish as the adjacent panels, unless otherwise indicated.

- a. The minimum face dimensions between flashing breaks shall be 12-inches (305 mm). Thermal expansion of exposed items more than 24-feet (7.3 m) in continuous length shall be accommodated and watertight expansion joints shall be provided at approved locations.
- b. Expansion joints shall be fabricated as approved of materials to match the flashing.
- c. Flashing and trim shall be minimum 20-gauge, formed, extruded metal fabricated with the same finish and color as the exterior face of the adjacent panels, unless otherwise indicated.
- d. WORK shall be coordinated as required to insure proper flashing and seals to adjoining construction.
- e. Flashing shall be provided for penetrations. Provide penetration enclosures, including hot pipe penetrations, to be weathertight. Coordinate locations of protruding pipes.

PART 3 -- EXECUTION

3.1 DELIVERY, STORAGE, AND HANDLING

- A. Deliver materials to Site in manufacturer's original, unopened packages, containers, or bundles with labels intact, which clearly identify contents.
 - 1. Materials shall be delivered to Site in a dry and undamaged condition and unloaded per the manufacturer's instructions. The installer shall inspect materials for damage and stains upon arrival to the Site.
- B. Store materials carefully in accordance with the manufacturer's written instructions, in an area that is protected from deleterious elements, and in a manner that will prevent damage to the products.
- C. Verify that foundation, floor slab, mechanical and electrical utilities, and placed anchors are in correct position.

3.2 PRODUCT CONDITIONS

- A. Comply with manufacturer's written instructions for environmental conditions before, during and after installation.
- B. Protect surrounds WORK from damage that may result from operations under this Section.

3.3 INSPECTION

- A. The Contractor shall be totally responsible for the proper performance and completion of the WORK under this Section.
- B. The Contractor shall inspect materials for damage and shall confirm conformance with the specifications, erection drawings, and shop drawings prior to installation.
- C. Systems and components shall be inspected before installation.

1. Damaged or defective items shall be rejected and marked as such and shall be removed from the Site.
 2. Exposed surfaces that exhibit pitting, seam marks, roller marks, stains, discoloration, or other surface imperfections on the finished units shall be rejected.
- D. The Contractor shall verify dimensions, tolerances, and method of attachment with adjacent WORK.
1. Examine substrates, areas, and conditions where metal wall, roof and soffit panels, system support framing, and appurtenances will be installed for compliances with the requirements for installation, taking into account tolerances, and other conditions affecting performances of installed metal panels and appurtenances.
 - a. Provide inserts, backing blocking, anchoring devices, and reinforcements that must be built into other WORK for the installation of metal wall, roof and soffit panels, system support framing, and appurtenances. Coordinate delivery with other WORK to avoid delay.
 - b. Prior to installing the pre-engineered metal building the Contractor and the pre-engineered metal building installer shall verify final alignment of the foundation, floor slab, mechanical and electrical utilities to be in compliance with these specifications with the Contract Documents, with the erection drawings, and with the shop drawings.
 2. Notify the Engineer in writing of conditions detrimental to the proper and timely completion of the WORK. Do not proceed with the WORK until satisfactory conditions have been corrected in an acceptable manner.
 3. Commencement of the installation by the Contractor shall indicate Contractor's acceptance of the substrate, areas, and conditions.

3.4 FABRICATION

- A. The building shall be factory fabricated and erected to the manufacturer's written standards and shall be in accordance with AISC and MBMA standards.
- B. The prefabricated building shall be completely fabricated and prepared for shipment including any necessary crating or bundling. All parts of the building shall be accurately made and true to dimension so that all parts will easily fit during installation.
- C. Wall Insulation: The exterior walls shall be insulated with 4-inch (102 mm) vinyl faced, fiberglass blanket insulation with an R-13 value.

3.5 GALVANIZING

- A. Galvanize structural steel plates shapes, bars, and fabricated assemblies required to be galvanized, after the steel has been thoroughly cleaned of rust and scale in accordance with the requirements of ASTM A123.
- B. Straighten any galvanized part that becomes warped during the galvanizing operation.
- C. Galvanize bolts, anchor rods, anchor bolts, nuts, and similar threaded fasteners, after being thoroughly cleaned in accordance with the requirements of ASTM A153.
- D. Field Repairs

1. Perform field repairs to damaged galvanizing by preparing the surface and applying a coating.
2. Surface preparation consists of removing oil, grease, soil, and soluble material by cleaning with water and detergent (SSPC SP1) followed by brush-off blast cleaning (SSPC SP7) over an area extending at least 4 inches into the undamaged area.
3. Apply the coating to at least 3 mils dry film thickness, and provide Zinc Clad XI by Sherwin-Williams, Galvax by Alvin Products, Galviline by ZRC Worldwide, or equal.

3.6 PREPARATION

- A. Sequence installation properly with the installation and protection of other WORK, so that neither will be damaged by the installation of the other.

3.7 INSTALLATION

A. General

1. Installation shall comply with the requirements of the Contract Documents, with applicable references, with AISC, AISI, MBMA, with the requirements of the CODE, and with manufacturer's written instructions. Where a conflict occurs among these requirements, the more stringent shall apply, as directed by the Engineer.
2. The Contractor shall provide corrosion resistant fasteners, anchors, and shims required for a complete installation, and shall be secure, plumb, level, straight, and true to line, allowing for required movement, including expansion and contraction.
3. The Contractor shall provide separation of dissimilar materials to ensure no galvanic action occurs.
 - a. Paint, bituminous coating, or sealant as recommended by the metal panel manufacturer shall separate dissimilar metals.
4. Horizontal lines shall be level, and vertical lines shall be plumb.
5. Manufacturer shall provide detailed instructions covering the tools, fasteners, sealants, gaskets, and procedures required to assure performance of the metal panel assembly.
6. WORK shall be coordinated as required to ensure proper flashing and seals to adjoining construction.
7. Install panels in one continuous length, without horizontal seams, joints or laps.

B. Installation and Erection

1. Installation and erection of the building shall be in accordance with the manufacturer's standards and shall be workmanship of the highest quality. No field cutting of structural parts will be permitted. Field cutting and patching of panels and accessories will not be permitted unless authorized by the PROJECT TEAM. Such field modifications, when authorized, shall be performed in a manner which will not impair the appearance, weather tightness, or structural quality of the material. Erection shall be accomplished in sufficient time to meet the schedule specified.

3.8 ROOF AND WALL PANELS

A. General: Apply panels and associated items for neat and weather tight enclosure. Avoid "panel creep" or application not true to line. Protect factory finishes from damage.

1. Flash and seal roof panels at eave and rake with rubber, neoprene or other closures to exclude weather.

B. Roof Panel Application

1. Panels shall be factory cut-to-length according to the erection drawings as furnished by the manufacturer.
2. Panels shall be positioned and aligned to hold the 24-inch (610 mm) module throughout the building length.
3. Pre-punched panels shall be positioned and aligned by matching the pre-punched holes in the panel with the pre-punched roof structural.
4. Panel sidelaps shall be field seamed; all sidelap sealant shall be factory applied.
5. Endlaps will be at least 6-inches (152 mm) and fastened together over and to structural members.
6. Panel sidelaps and endlaps shall be sealed with weather sealing compound to prevent the entry of capillary moisture.
7. Fasteners shall be installed with proper tools, in a workmanlike manner according to the recommendations of the Manufacturer.

C. Wall Panel Application

1. Structural system shall be plumb before wall panels are attached.
2. Panels shall be aligned and attached in accordance with the erection drawings.
3. Sidelaps shall be at least one corrugation.
4. Panels shall be closed at base by metal closure.

3.9 CLEANING, FINISHING, AND PROTECTION

A. Adhesive papers used for masking which become firmly bonded when exposed to heat and/or light shall not be used.

1. Remove masking film and temporary labels as soon as possible after installation. Films and labels left in place after installation shall be the responsibility of the Contractor.
2. Residue shall not be left on any surfaces.

B. Upon completion of the installation of pre-engineered metal building and appurtenances shall be cleaned of dirt and other foreign matter to the satisfaction of the Owner.

- C. Cleaning shall be performed again immediately prior to acceptance of the WORK, as determined by the Engineer.
 - 1. Cleaning shall be performed in accordance with the manufacturer's written instructions.
 - 2. Pre-engineered metal building shall be protected from damage from subsequent construction operations.
- D. The Contractor shall make adjustments required until accepted.
- E. The Contractor shall remove scratches and blemishes to the satisfaction of the Owner.
- F. Damaged or defective items shall be removed and replaced at the direction of the Owner.
- G. When pre-engineered metal building WORK is completed, remove unused materials, containers, and equipment, and clean the Site of debris.

END OF SECTION

SECTION 22 10 00 – PLUMBING PIPING

PART 1 -- GENERAL

1.01 SUMMARY

- A. The Contractor shall provide plumbing piping and specialties, complete and operable, as indicated in accordance with the Contract Documents.

1.02 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

A. Reference Specifications

01 33 00	Submittal Procedures
01 33 17	Structural Design, Support and Anchorage
09 96 00	High-Performance Coatings
23 07 00	HVAC Insulation
40 05 07	Hangers and Supports for Process Piping
40 05 63	Ball Valves
43 30 52	Miscellaneous Valves

B. Reference Standards

American National Standards Institute (ANSI)
American Society of Mechanical Engineers (ASME)
International Organization for Standardization (ISO)
American Society of Sanitary Engineering (ASSE)
American Society for Testing and Materials (ASTM)
American Water Works Association (AWWA)
National Sanitation Foundation (NSF)
Safe Drinking Water Act (SDWA)
United States Environmental Protection Agency (US EPA)

1.03 CONTRACTOR SUBMITTALS

- A. Furnish submittals in accordance with Section 01 33 00 – Submittal Procedures.

B. Shop Drawings

1. General arrangement drawings of system components
2. Catalog cuts and other manufacturer information for products

- C. Samples: electrically fused test joint for drainage and vent piping

1.04 WORKMANSHIP AND MATERIALS

- A. Work shall be in strict accordance with the Ohio Plumbing Code and codes of the City of Warren, and any other authorities having jurisdiction.

- B. The Contractor shall have required certifications and shall be thoroughly familiar with the local codes.
- C. The Contractor shall obtain and pay for necessary permits.
- D. Protection
 - 1. Care shall be taken at all times to protect floors, stairways, and walls during the make-up and installation of piping and equipment.
 - 2. The Contractor shall remove stains and repair damage before final acceptance of the Work.
- E. Identifying Marks
 - 1. If the Engineer finds materials that have identifying marks removed or lack such marks completely, such items will be rejected until the Contractor has furnished proof that said items conform to the Specifications.
 - 2. Adequacy and extent of such proof will be determined by the Engineer.

PART 2 -- PRODUCTS

2.01 GENERAL

- A. Plumbing piping, fixtures, specialties, and equipment shall be as recommended by the manufacturer for the intended usage.
- B. Floor drains or floor sinks shall be provided for equipment drains.
- C. No equipment drains shall discharge to floor slabs.
- D. Any pipe, plumbing fitting or fixture, solder, or flux used in the installation or repair of any public water system or any plumbing in a facility providing water for human consumption, shall be "lead free" except when necessary for the repair of leaded joints of cast iron pipes.
 - 1. Lead free products shall meet or exceed the requirements of the Safe Drinking Water Act (SDWA) - USEPA.
 - 2. Lead free is defined as not more than 0.2 percent lead when used with respect to solder and flux; not more than 0.25% in the wetted surface material of pipes, pipe fittings, plumbing fittings and fixtures.

2.02 POTABLE WATER

- A. Copper tubing and fittings for potable and service water 3-inch and smaller shall be Type K copper tube with soldered fittings and shall conform to ASTM B88M ASTM B88
- B. Solder containing lead shall not be used with copper pipe.
- C. Solder Material: Solder metal shall conform to ASTM B32.

- D. Solder Flux: Flux shall be liquid form, non-corrosive, and conform to ASTM B813, Standard Test 1.
- E. Material or equipment containing a weighted average of greater than 0.25 percent lead shall not be used in any potable water system intended for human consumption, and shall be certified in accordance with NSF/ANSI 61, Annex G or NSF 372.
- F. In line devices such as water meters, building valves, check valves, meter stops, valves, fittings and back flow preventers shall comply with PL 93-523 and NSF/ANSI 61, Section 8. End point devices such as drinking water fountains, lavatory faucets, kitchen and bar faucets, residential ice makers, supply stops and end point control valves used to dispense water for drinking must meet the requirements of NSF/ANSI 61, Section 9.

2.03 PVC PIPING AND FITTINGS FOR SANITARY DRAIN, STORM DRAIN AND VENTS

- A. PVC Schedule 40 corrosion resistant sanitary pipe, IPS sizes 1/8" through 24", shall be rated for temperatures up to and including 200 °F, and Pressure rating (120 psi to 810 psi) depending on pipe schedule, pipe size, and temperature as stated in Harvel Plastics, Inc. engineering bulletin (Product Bulletin 112/401). Pipe shall be suitable for PVC plastic drain, waste, and vent (DWV) applications. Pipe material shall be generally resistant to most acids, bases, salts, aliphatic solutions, oxidants, and halogens. Chemical resistance data is available and should be referenced for proper material selection. Pipe exhibit excellent physical properties and flammability characteristics (independently tested flame and smoke characteristics-ULC). Typical applications include: chemical processing, plating, high purity applications, potable water systems, water and wastewater treatment, drainage, irrigation, agricultural, and other applications involving corrosive fluid transfer.
- B. This specification outlines minimum manufacturing requirements for Polyvinyl Chloride (PVC) Schedule 40 iron pipe size (IPS) pressure pipe. This pipe is intended for use in applications where the fluid conveyed does not exceed 200°F. This pipe shall meet and or exceed the industry standards and requirements as set forth by the American Society for Testing and Materials (ASTM D1785 & D2665) and the National Sanitation Foundation (NSF International STD 61 & Std 14).
- C. The material used in the manufacture of the pipe shall be domestically produced rigid polyvinyl chloride (PVC) compound, Type I Grade I, with a Cell Classification of 12454 as defined in ASTM D1784, trade name designation H707 PVC. This compound shall be white or gray in color as specified, and shall be approved by NSF International for use with potable water (NSF Std 61).

- D. All sizes of PVC Schedule 40 pipe shall be manufactured in strict accordance to the requirements of ASTM D1785 for physical dimensions and tolerances. PVC Sch 40 pipe sizes 1-1/2" through 24" diameters shall also meet the requirements of ASTM D2665 Standard Specification for PVC plastic drain, waste and vent (DWV) pipe and shall be dual marked as such. Each production run of pipe manufactured in compliance to the standard, shall also meet or exceed the test requirements for materials, workmanship, burst pressure, flattening, and extrusion quality defined in ASTM D1785 and ASTM D2665 as applicable. All belled-end pipe shall have tapered sockets to create an interference-type fit, which meet or exceed the dimensional requirements and the minimum socket length for pressure-type sockets as defined in ASTM D2672. All PVC Schedule 40 pipe must also meet the requirements of NSF Standard 14 and CSA Standard B137.3 rigid PVC pipe for pressure applications, and shall bear the mark of these Listing agencies. This pipe shall have a flame spread rating of 0-25 when tested for surface burning characteristics in accordance with CAN/ULC-S102-2-M88 or equivalent.
- E. Product marking shall meet the requirements of ASTM D1785 and ASTM D2665 as applicable and shall include: the manufacturer's name (or the manufacturer's trademark when privately labeled); the nominal pipe size; the material designation code; the pipe schedule and pressure rating in psi for water @ 73°F; the ASTM designation D1785; the ASTM designation D2665 (when dual marked); the independent laboratory's seal of approval for potable water usage; and the date and time of manufacture.
- F. All PVC Schedule 40 pipe shall be manufactured from a Type I, Grade I Polyvinyl Chloride (PVC) compound with a Cell Classification of 12454 per ASTM D1784. The pipe shall be manufactured in strict compliance to ASTM D1785 and D2665 (where applicable), consistently meeting and/or exceeding the Quality Assurance test requirements of these standards with regard to material, workmanship, burst pressure, flattening, and extrusion quality. The pipe shall be manufactured in the USA, using domestic materials, by an ISO 9001 certified manufacturer. Standard lengths of pipe sizes 6" and larger shall be beveled each end by the pipe manufacturer. All pipe shall be stored indoors after production at the manufacturing site until shipped from factory. This pipe shall carry the National Sanitation Foundation (NSF) seal of approval for potable water applications.

2.04 INSULATION

- A. Hot and cold water piping, valves, fittings, and exposed horizontal sanitary, storm, and vent piping shall be provided with one-inch-thick insulation in accordance with the requirements of Section 23 07 00 – HVAC Insulation.
- B. Coverings
 - 1. Cover valves, flanges, fittings, and ends-of-insulation with a pre-molded high- and low-temperature PVC fitting cover, end cap, or similar pre-formed unit.
 - 2. The pre-formed covers shall be sized to receive the same thickness of insulation as used in the adjacent piping and shall be in accordance with Section 23 07 00 – HVAC Insulation.
- C. Exposed Piping

1. Exposed supply and drain piping shall be insulated and jacketed with ADA compliant safety cover under all lavatories in order to prevent burns and abrasions to handicapped persons.
2. Removable insulated covers shall be Plumberex Specialty Products Handy-Shield type, or equal.

2.05 HANGERS, SUPPORTS, AND MISCELLANEOUS METAL WORK

A. General

1. For utility piping such as cold water, hot water, compressed and vacuum air, and sanitary piping located inside the building, the Contractor shall provide hangers and supports for vertical, axial, and seismic loads in accordance with the Code, and per Section 01 33 17 – Structural Design, Support and Anchorage.
2. No perforated strap hangers nor wire supports will be permitted.
3. The Contractor shall obtain the services of a registered mechanical or structural professional engineer for design of the supports, and the Shop Drawings showing installation shall be stamped by the registered engineer.
4. Pipe supports shall be as indicated in Section 40 05 07 – Hangers and Supports for Process Piping.

B. Hangers supporting insulated piping shall be sized to fit the pipe plus the insulation.

C. Insulation at support points shall be provided with metal shields in order to prevent damage to the insulation.

D. Spacing

1. Pipe support spacing for steel and cast-iron pipe shall be as indicated in Section 40 05 07 – Hangers and Supports for Process Piping.
2. Copper tube support spacing shall be not more than 6 feet between supports.

E. Rod sizes for pipe hangers shall be as recommended by the hanger manufacturer.

F. Pipe hangers used to support uninsulated copper tube shall be constructed of copper or copper plated.

G. Vertical piping shall be supported at the base with fittings made for this purpose or shall be supported from the nearest horizontal member or floor with a riser extension pipe clamp.

H. Inserts

1. Anchors that are installed into existing concrete shall be Grinnell Figure 117, Modern Figure 740, or equal, expansion case inserts.
2. Drill clean holes for the insertion of case and patch concrete around the hole, as required.

3. Continuous-slotted concrete inserts, if used, shall be Crawford Figure 148, Fee & Mason Figure 9000, or equal.
4. The Contractor shall provide secondary angle supports between main inserts in order to handle the loads which can be properly supported by such arrangement.
5. Concrete inserts shall be as indicated in Section 40 05 07 – Hangers and Supports for Process Piping.
6. Inserts shall be galvanized.

2.06 PIPE SLEEVES

- A. Sleeves shall be constructed from Schedule 40 galvanized steel pipe, one size larger than the pipe passing through, or where pipe is insulated, one size larger than the pipe plus insulation.
- B. At exposed wall or ceiling surfaces, install a suitable chromium plated brass wall plate approved by the Engineer.
- C. At exterior wall pipe penetrations, the space between the sleeve and pipe shall be made watertight with a modular or link rubber seal. The link seal shall be applied at both ends of the sleeve.
- D. To prevent accidental liquid spills from passing to a lower level, provide the following:
 1. For sleeves: Extend sleeve 1 inch above finished floor and provide sealant for watertight joint.
 2. For blocked out floor openings: Provide 1 1/2 inch angle set in silicone adhesive around opening.
 3. For drilled penetrations: Provide 1 1/2 inch angle ring or square set in silicone adhesive around penetration.
- E. Pipe penetration sleeve materials shall comply with all fire stopping requirements for each penetration. Caulk opening at fire-rated walls minimum one-half inch depth with an approved fire barrier caulk.

2.07 VALVES

- A. Water shutoff valves shall be of the ball valve type, including on fixture supply piping.
- B. Hose Valves
 1. Interior hose valves shall be provided as indicated.
 2. The hose nipple shall be a female iron pipe thread inlet with hose thread outlet.
 3. Hose bibbs shall be 1-inch size.
- C. Ball valves shall be in accordance with the requirements of Section 40 05 63 - Ball Valves.
- D. Ball Shut-Off Valves

1. Provide ball shut-off valves on cold water piping at entrances to pipe chases and other inaccessible areas and wherever indicated or required to obtain the maximum efficiency for shut-off control on the water system.
2. Ball shut-off valves shall be placed on hot and cold water connections to equipment and fixtures.
3. Show the locations of shut-off valves on the Shop Drawings.

E. Relief Valves

1. Provide a temperature and pressure relief valve of bronze for each water heater.
2. Provide pressure relief valves at other locations where indicated.
3. Relief valves shall be equipped with manual test levers.
4. Provide piping to convey the relief valve discharge to the nearest floor drain, the building exterior, or elsewhere if approved by the Engineer.

2.08 ACCESS DOORS AND COVERS

- A. Access doors, where required in ceilings for access to valves, controls, and other equipment, shall be Karp Assoc., Style DSC-210, Inryco-Milcor, Style AT, or equal.
- B. The doors shall be of sufficient size to allow access but shall be not less than 12-inch by 12-inch.
- C. Ceilings with lay-in acoustical tile do not require access panels.
- D. Valves and equipment located above ceiling tile shall have a 3/4-inch-diameter blue plastic button with a letter "V" set in the tile.

E. Floor Covers

1. Floor access covers in unfinished concrete floors not exposed to chemicals shall be constructed of galvanized cast iron with a clear opening of not less than 8-inch by 8-inch, and shall be Alhambra Foundry Company, Model A-2015, Neenah Foundry Co., No.R-6687, or equal.
2. In traffic or chemical areas, access covers shall be Alhambra Foundry Company, Model A-1240, Neenah Foundry Co., Model R-1977, or equal, with a clear opening of not less than 10 inches in diameter.

2.09 FLOOR DRAINS IN TILED FLOORS

- A. Floor drains in shower rooms and other finished or tiled floors shall be provided with a 5-inch nickel-bronze strainer and cast-iron body in the sizes indicated, and where located on upper floors provided with a clamping collar with 4-lb sheet lead flashing 12 inches minimum all around.
- B. Manufacturers, or Equal
 1. Josam Mfg. Co., Series 30 000-A

2. Jay R. Smith Mfg. Co., Fig. 2010-A
3. Zurn Industries, Inc., Series ZN-415-C

2.10 FLOOR DRAINS IN CONCRETE FLOORS

- A. Floor drains in concrete floors shall be constructed of cast iron, in the sizes indicated, and provided with sediment buckets.
- B. Each floor drain located on an upper floor shall have a clamping collar, with 4-lb sheet lead flashing 12 inches minimum all around.
- C. Where lead flashing does not comply with the Code, use epoxy waterproofing material, and submit a Shop Drawing for review.
- D. Manufacturers, or Equal
 1. Josam Mfg. Co., Series 32100-AE-81
 2. Jay R. Smith Mfg. Co., Fig. 2350
 3. Zurn Industries, Inc., Series Z-520-Y

2.11 CITY WATER FLOW METER

- A. Potable Water Flow Meter shall be produced in an ISO9001 certified production facility and shall be constructed in conformance with AWWA C708 standards. The product shall comply with NSF/ANSI 61 Annex G and conforms with lead-free plumbing as defined by state laws and the U.S. Safe Drinking Water Act.
- B. The main case of the flow meter shall be constructed using C87850 low-lead brass alloy.
- C. All parts in contact with water shall be constructed of corrosion-resistant materials.
- D. Body and coupling shall be made with low-lead brass alloy C87850 and shall meet potable water standards.
- E. Such include an optional pulse output consisting of plastic housing with 2-wire (red and black) reed switch and cable.
- F. Pressure range shall be up to 150 PSI.
- G. Temperature range shall be up to 122°F.
- H. Normal Flow Accuracy: $\pm 1.5\%$
- I. Low flow Accuracy: $\pm 3\%$
- J. Materials of Construction
 1. Body and Couplings: EcoBrass
 2. Internals: Engineered thermoplastic
 3. Magnet: Alnico

K. Manufacturers, or Equal

1. Assured Automation, WM-NLC Series

2.12 CLEANOUTS

A. Cleanouts shall be heavy plugs with tapered shoulders against caulked lead or heavy brass plugs.

B. Where underground or concealed, cleanouts shall be brought to floor level and to accessible locations with access covers and frames.

C. Manufacturers, or Equal

Service	Josam Series	J.R. Smith No.	Zurn No.
Exposed Locations	58500-20	4405	Z-1440-A
Underground (finished floors)	56010/30	4143	ZN-1400-2
Walls, Concealed	58790-20	4535	ZN-1445-1-A
Traffic Areas	56070	4240	Z-1420-27

D. Cleanouts shall have a minimum diameter of 3 inches.

E. Stack cleanouts shall be installed at the base of each stack.

F. Cleanouts shall be fabricated from galvanized cast iron with ABS plastic cleanout plugs.

2.13 HOSE BIBBS AND HYDRANTS

A. Hose bibbs and hydrants in exposed locations subject to freezing shall be the non-freeze type.

B. Hose bibbs connected to a non-potable water supply shall be provided with plastic or stainless steel warning signs reading "DO NOT DRINK" in clearly legible letters, permanently attached at the hose bibb.

C. Hose bibbs shall be provided with vacuum breakers as furnished by Crane Co., American Standard, or equal.

D. Manufacturers or Equal

Drawing Callout	Fixture Type	Description
HB-1	Indoor Hose Bibb	Exposed, anti-siphon, wall faucet for indoor installation, complete with Z1399-BFP external backflow preventer, all bronze interior components, vandal-resistant operating stem, rough bronze exterior and ¾ male hose connection (Conform to ASME B1.20.7). Zurn Industries, Inc., Model Z1341-BFP

HB-2	Non-Freeze Hydrant, Wall-Type	Heavy duty bronze hydrant with nickel-bronze face, hinged cover, recessed box, and key. Length to suit wall. Jay R. Smith Mfg. Co., Fig. 5509 Josam Mfg. Co., Zurn Industries, Inc.,
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2.14 SHOCK ABSORBERS

- A. Building cold and hot water piping that is connecting self-closing faucets, quick-action valves, water closets, emergency showers, washers, and dishwashers, shall be protected by shock absorbers located at each fixture or battery of fixtures.
- B. Shock absorbers shall be corrosion-resistant, permanently sealed, and shall be sized and installed to the manufacturer's printed recommendations.
- C. Manufacturers, or Equal
 - 1. Josam "SHOKTROLS"
 - 2. Jay R. Smith "HYDROTROL"
 - 3. Zurn, Model Z-1022

2.15 WALL-MOUNTED HOSE RACKS

- A. The Contractor shall provide wall-mounted hose racks at the indicated locations.
- B. Racks shall be of welded steel construction, minimum 8-gauge sheet steel, hot-dip galvanized after fabrication, and shall have a capacity to hold 100 feet of the indicated hose.
- C. Racks located in the open shall be supported from two 2-by-2-by-1/4-inch galvanized steel angle posts set in a concrete base or as indicated.

2.16 HOSES AND NOZZLES

- A. The Contractor shall furnish the following lengths of hose:
 - 1. 100' lengths of 75-ft long, 3/4-inch hose.
 - 2. 100' lengths of 75-ft long, 1-1/2-inch hose.
 - 3. 100' lengths of 75-ft of 2-1/2-inch hose.
 - a. Each length of hose shall be provided with male and female connectors and a nozzle.
 - b. Hoses shall be fabricated from seamless extruded rubber designed for a working pressure of at least 300 psig and shall be suitable for industrial applications.
 - c. Hoses shall be oil resistant reinforced to provide kink resistance.

- d. Hoses shall be provided with brass threaded fittings, for hose bib and nozzle connection.
 - e. Temperature range is -20 °F to 180 °F.
- 4. Hoses Manufacturers, or Equal
 - a. Flexicraft, Model RM1
- B. Nozzles:
 - 1. Nozzles shall be capable of complete shut-off and shall produce a solid straight stream and up to a 90-degree conical fog.
 - 2. Nozzle material shall be polished brass.
 - 3. Nozzles shall be provided with rubber bumpers.

2.17 BACKFLOW PREVENTER

- A. Provide reduced pressure backflow prevention units where indicated.
- B. The valve shall be designed to be installed either vertically or horizontally.
- C. The units shall be of bronze body construction, with celcon check seats and stainless steel relief valve seats, shafts, and bolts.
- D. The units shall be provided with tight-seating check valve and relief assemblies, and bronze bodies with non-rising stem ball valve test cocks.
- E. The units shall be Watts Regulator Co., No. LF909 Series, or Engineer approved equal.
- F. Installation shall meet local code requirements.
- G. Nozzle Manufacturers, or Equal
 - 1. W.D. Allen Mfg. Co.
 - 2. Fire-End and Croker Corp.
 - 3. Halprin Supply Co.
 - 4. Western Fire Equipment Co.

2.18 WASH DOWN MONITOR (WATER CANNON)

- A. The wash-down monitor shall be of brass construction with a cast iron lever handle.
- B. The monitor shall be capable of full 360-degree swivel and shall deliver 500 gallons per minute.
- C. Manufacturers, or Equal
 - 1. Croker

2.19 HIGH IMPACT SPRAY NOZZLES

- A. Provide 3/4-inch high-impact jet spray nozzles, with a flat 65-degree spray angle and male thread connections.
- B. The capacity of the nozzle shall be 20 gpm at 40 psi head, and its material shall be Type 316 stainless steel.
- C. Manufacturers, or Equal
 - 1. Veejet-Spray Nozzles, Model HU-3/4-316SS-8040

2.20 PAINTING

- A. Ferrous metal, except finished, galvanized, and machined surfaces, shall have surfaces prepared and primed in the shop in accordance with the requirements of Section 09 96 00 – High-Performance Coatings.
- B. Prime colors shall be compatible with finish coats that are applied in the field.
- C. Self-contained units such as wall-mounted hose racks shall be supplied with factory-applied finish coats of baked enamel.
- D. Field painting shall comply with the requirements of Section 09 96 00 – High-Performance Coatings.

PART 3 -- EXECUTION

3.01 PREPARATION

- A. The Contractor shall coordinate the roughing-in process with provisions for wall and floor sleeves, pipe inserts, and cutting of roof and floor penetrations, such that drain lines will have the required invert elevations and slopes.

3.02 OPENINGS

A. New Construction

- 1. The Contractor shall provide necessary openings in walls, floors, and roofs for the passage of piping and plumbing equipment within and into the building.
- 2. Openings shall be as indicated or as required to provide passage for the plumbing Work.

B. Existing Construction

- 1. The Contractor shall provide openings required in existing walls, floors, and roofs for the passage of piping and plumbing equipment.
- 2. Openings shall be as indicated or required for passage.
- 3. Openings shall be cut in a neat and orderly manner, minimizing damage to existing structures.
- 4. Patching of openings shall match existing construction.

5. The Contractor shall be responsible for hangers and supporting members installed in existing masonry or structural steel as required for the proper completion of the Work.

3.03 INSTALLATION AND APPLICATION

- A. The Contractor shall provide plumbing specialties in accordance with manufacturer's printed instructions.
- B. Pipe shall be arranged in a neat and orderly manner to occupy the minimum amount of space and so that the pipe will not obstruct passageways and movement of building occupants or interfere with normal operation and maintenance of any equipment.
- C. Pipe shall be carefully placed and properly sloped and shall be neatly and firmly supported by hangers or supports.
- D. Piping in buildings shall be as close to the ceilings or walls as possible unless indicated otherwise.
- E. Joints
 1. Screwed joints shall be made with joint compound and be tight and leak-proof.
 2. A sufficient number of brass-to-ferrous metal seat unions shall be placed in lines such that any pipe, valve, or piece of equipment may be easily disconnected.
- F. Drainage and Sanitary Lines
 1. Drainage and sanitary lines shall be properly run, trapped, and vented in order to conform to Code requirements.
 2. Changes in direction shall be made with "Y" branch fittings and shall be of the same size as the pipe.
 3. Changes in pipe size shall be made with reducing fittings.
 4. The minimum depth of cover shall be 3 feet.
- G. Horizontal soil, drain, and waste pipes shall be provided with a slope of at least 1/4 inch per foot, unless indicated otherwise.
- H. Floor drains and cleanouts shall be installed such that the tops of the drains are flush with the finished floor.
- I. Joints in PE pipe shall be installed such that the longitudinal pull out resistance of each joint is at least equal to the tensile strength of the pipe.

3.04 EQUIPMENT DAMAGE AND REMOVAL

- A. The Contractor's operations shall be carried out in such a manner as to guard against damage to those portions of the structure and equipment that are to remain in the finished Work.
- B. Any damage caused by the Contractor or Subcontractor through their operations shall be repaired to the satisfaction of the Engineer.

3.05 TESTING

- A. The Contractor shall perform such tests as are required by local ordinances and Codes in the presence of a local governing authority inspector to show that piping is tight, leak-free, and otherwise satisfactory, and shall also perform such tests as the Engineer may direct to ensure that fixtures and equipment operate properly.
- B. The Contractor shall pay the costs to perform such tests and the costs of making changes or repairs until the WORK is acceptable to the governing authorities.
- C. Potable Water and Drainage Piping Pressure Testing
 - 1. Demonstrate to an Owner witness that the piping passes the following pressure tests before it is insulated or covered by walls or ceilings. Test piping after all fittings and valves for that portion of the piping have been installed.
 - 2. All pressure testing shall be witnessed and documented with results approved and signed off by an Owner representative.
 - 3. Repair leaks discovered during pressure testing. Retest failed sections of piping to demonstrate satisfactory results.
 - 4. Potable Water Testing: Upon completion of a section or of the entire hot and cold water supply system, it shall be tested and proved tight under a water pressure not less than one and half time of the working pressure under which it is to be used, but not less than 125 psi. The water used for tests shall be obtained from a potable source of supply. The piping shall withstand the test without leaking for a period of not less than 15 minutes.
 - 5. Drainage Water Testing: The drainage, and venting systems shall be tested with water. The water test shall be applied to the drainage and vent systems either in its entirety or in sections. Where the test is applied to the entire system, openings in the piping shall be tightly closed, except the highest opening, and the system filled with water to point of overflow. Where the system is tested in sections, each opening shall be tightly plugged, except the highest opening of the section under test, and each section shall be filled with water, but no section shall be tested with less than a 10-foot head of water. In testing successive sections, not less than the upper 10 feet of the next preceding section shall be tested, so that no joint or pipe in the building (except the uppermost 10 feet of the system) shall have been submitted to a test of less than a 10-foot head of water. The water shall be kept in the system, or in the portion under test, for not less than 15 minutes before inspection starts. The system shall then be tight at all points.

3.06 DISINFECTION

- A. The line shall then be filled with water and maintained under not less than 10 psig pressure, for not less than 48 hours, during which period each valve on the line shall be opened and closed several times, after which it shall be flushed clean and then tested by the Owner.
- B. After potable water supply lines are successfully pressure tested, they shall be disinfected by introducing an HTH solution, liquid chlorine, or chlorine solution of sufficient strength.

- C. Potable water systems shall be purged of deleterious matter and disinfected prior to utilization. The method to be followed shall be that prescribed by the health authority or water purveyor having jurisdiction or, in the absence of a prescribed method, the procedure described in either AWWA C651 or AWWA C652, or as described in this section.
 - 1. The pipe system shall be flushed with clean, potable water until dirty water does not appear at the points of outlet.
 - 2. The system or part thereof shall be filled with a water/chlorine solution containing not less than 50 parts per million (50 mg/L) of chlorine, and the system or part thereof shall be valved off and allowed to stand for 24 hours; or the system or part thereof shall be filled with a water/chlorine solution containing not less than 200 parts per million (200 mg/L) of chlorine and allowed to stand for 3 hours.
 - 3. Following the required standing time, the system shall be flushed with clean potable water until the chlorine is purged from the system.
 - 4. The procedure shall be repeated where shown by a bacteriological examination that contamination remains present in the system.
- D. This procedure shall be repeated as often as necessary until the line is pronounced safe for use by the Owner.
- E. No cross-connection between the water main and any pipe not yet disinfected will be permitted.

END OF SECTION

SECTION 22 30 00 – PLUMBING EQUIPMENT

PART 1 -- GENERAL

1.01 SUMMARY

- A. The Contractor shall provide plumbing fixtures and plumbing equipment as indicated, complete with water, gas and electric connections and hook-ups, for a complete and operable installation as indicated in accordance with the requirements of the Contract Documents.

1.02 CONTRACTOR SUBMITTALS

- A. Furnish submittals in accordance with Section 01 33 00 – Submittal Procedures.
- B. Shop Drawings
1. Certified pump curves for each pump
- C. O&M Data
1. Submittals shall include operation, maintenance, and inspection data, replacement part numbers and availability, and service depot location and telephone number.

1.03 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

A. Reference Specifications

01 33 00	Submittal Procedures
01 33 17	Structural Design, Support and Anchorage
26 05 10	Low-Voltage Electrical Motors

A. Reference Standards

American National Standards Institute (ANSI)	
ANSI Z21.10.3	(2019) Gas-Fired Water Heaters Vol.III, Storage Water Heaters with Input Ratings Above 75,000 Btu Per Hour, Circulating and Instantaneous
American Petroleum Institute (API)	
American Society of Mechanical Engineers (ASME)	
API-ASME Code	Unfired Pressure Vessels for Petroleum Liquids and Gases
American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE)	
ASHRAE 93-1986	Methods of Testing to Determine the Thermal Performance of Solar Collectors
Ohio Energy Code (OBC Chapter 13)	
OBC 2018	2018 Ohio Building Code
Canadian Standards Association (CSA)	
International Energy Conservation Code (IECC)	
Solar Rating and Certification Corporation (SRCC)	

SRCC OG-300	(2015) Solar Thermal System Certification Program
Underwriters Laboratories (UL)	
UL 508	(2018; Reprint Jul 2021) UL Standard for Safety Industrial Control Equipment

PART 2 -- PRODUCTS

2.01 GENERAL

- A. Plumbing piping, fixtures, specialties, equipment, and appurtenances shall be new, first-quality products manufactured for the intended usage.
- B. Materials, capacities, features, finishes, and manufacturers shall be as indicated and shall be compatible with elements of the Work to which they relate or connect.
- C. Any pipe, plumbing fitting or fixture, solder, or flux used in the installation or repair of any public water system or any plumbing in a facility providing water for human consumption, shall be "lead free" except when necessary for the repair of leaded joints of cast iron pipes.
 - 1. Lead free is defined as not more than 0.2 percent lead when used with respect to solder and flux, not more than 0.25 percent in the wetted surface material of pipes, pipe fittings, plumbing fittings and fixtures.

2.02 INSTANTANEOUS ELECTRIC WATER HEATER

- A. Provide an electric instantaneous water heater of the size and capacity as indicated.
- B. Control
 - 1. The unit shall be microprocessor controlled.
 - 2. When a hot water tap is opened, the cold water entering the heater shall pass over a thermostat, turning on an electrical heat coil that shall heat the water up to 125 degrees °F.
 - 3. As the mixture of hot and cold water is adjusted, other converting thermostats shall recalculate the flow of energy sequentially adding or subtracting energy to maintain a constant temperature.
 - 4. When the hot water is turned off, the flow of energy shall turn off as well.
- C. The heater shall be UL-listed and shall be guaranteed for life against leakage and rupture.
- D. Instantaneous electric water heaters shall meet requirements as scheduled.
- E. Manufacturers, or Equal
 - 1. Option 1: Chronomite SR
 - 2. Option 2: EEMax

2.03 PRESSURE GAUGES

- A. Pressure gauges shall consist of:
 - 1. Minimum 4-1/2-inch diameter dial
 - 2. Cast aluminum case
 - 3. Zero adjustment
 - 4. Phosphor bronze or stainless bourdon tube and socket
 - 5. Stainless steel movement
 - 6. Double strength glass window
 - 7. White face with black embossed figures and graduations
- B. Pressure gauges shall have a guaranteed accuracy of 1/2 to one percent of the scale range.
- C. The pressure range shall be 0-60 psig.
- D. Provide each pressure gauge with a pigtail siphon and a 3-way cock.
- E. Pressure gauges shall be arranged such that they may be read from the operating floor.
- F. Manufacturers or Equal
 - 1. Ashcroft Maxisafe Durogauge
 - 2. Wexsler

2.04 THERMOMETERS

- A. Thermometers shall have a temperature range of 50-250 degrees °F.
- B. Thermometers shall be of an "every angle" design and shall include a 9-inch aluminum case and a chrome plated brass joint with a locking device.
- C. The bulb material shall be copper plated steel.
- D. Thermometers shall have a "red reading" mercury tubing protected by a dust-tight cover glass.
- E. Stem
 - 1. The stem shall be located in an elbow or tee.
 - 2. The stem length shall be not less than 9 inches, and shall extend into the piping being served not less than 3/4 of the diameter of the pipe.
- F. Thermometers shall be arranged such that they may be read from the operating floor.
- G. Manufacturers or Equal

1. Ashcroft, Industrial Glass Type

2. Wexsler

PART 3 -- EXECUTION

3.01 WATER HEATER INSTALLATION

- A. The Contractor shall install the water heaters in accordance with the manufacturer's printed instructions.
- B. The Work shall be coordinated with plumbing piping and related electrical Work.
- C. The Contractor shall provide aluminum pipe supports for tanks, independent of building structural framing members.
- D. Tanks shall be cleaned and flushed after installation but prior to Startup.
- E. Equipment openings shall be sealed until piping connections are made.

END OF SECTION

SECTION 22 40 00 – PLUMBING FIXTURES

PART 1 -- GENERAL

1.01 SUMMARY

- A. The Contractor shall provide plumbing fixtures, complete and operable, as indicated in accordance with the Contract Documents.

1.02 CONTRACTOR SUBMITTALS

- A. Furnish submittals in accordance with Section 01 33 00 – Submittal Procedures.

B. Shop Drawings

1. Show material type, material thickness, sinks, counters, splashes, drawers, shelves, legs, frame, supports, and anchors or fasteners for the counter sink unit.

1.03 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

A. Reference Specifications

01 33 00	Submittal Procedures
07 92 13	Elastomeric Joint Sealants

B. Reference Standards

American Bureau of Shipping (ABS)	
Americans with Disabilities Act (ADA)	
American National Standards Institute (ANSI)	
NSF/ANSI 61	(2020) Drinking Water System Components – Health Effects
ANSI A112.6.1	Floor-Affixed Supports for Off-the-Floor Plumbing Fixtures for Public Use
ANSI A112.18.1	Plumbing Fixture Fittings
ANSI A112.18.1M	Plumbing Fixture Fittings
ANSI A112.19.1	Enameled Cast Iron Plumbing Fixtures
ANSI A112.19.2	(1973) Vitreous China Plumbing Fixtures
ANSI A112.19.4	(1994) Porcelain Enameled Formed Steel Plumbing Fixtures (with Supplement and Errata)
ANSI A112.19.5	Trim for Water Closet Bowls, Tanks and Urinals
ANSI A117.1	(2009) Accessible and Usable Buildings and Facilities
ANSI Z124.2	(1995) Plastic Shower Units
ANSI Z358.1	(2014) American National Standard for Emergency Eyewash and Shower Equipment
American Society of Mechanical Engineers (ASME)	
ASME A112.19.2	(2018) Ceramic Plumbing Fixtures
ASME A112.6.1M	(1997) Floor-Affixed Supports for the Off-the-Floor Plumbing Fixtures for Public Use

ASME A112.6.2	Floor Affixed Supports for Off-the-Floor Plumbing Fixtures for Public Use
American Society of Sanitary Engineering (ASSE)	
ASSE 1070	(2015) Performance Requirements for Pressurized Flushing Devices for Plumbing Fixtures
ASSE 1071	(2012) Performance Requirements for Temperature Actuated Mixing Valves for Plumbed Emergency Equipment
California Building Code (CBC)	
International Code Council (ICC)	
NSF International (NSF)	

PART 2 -- PRODUCTS

2.01 GENERAL

- A. Reference Standards: Products in this section shall be built, tested, and installed in compliance with the following quality assurance standards; latest editions, unless noted otherwise.

International Plumbing Code with local amendments.	
NSF/ANSI-61	G Drinking Water System Components - Health Effects
ANSI A112.6.1	Supports for Off-the-Floor Plumbing Fixtures for Public Use
ANSI A112.18.1	Finished and Rough Brass Plumbing Fixture Fittings
ANSI A112.19.1	Enameled Cast Iron Plumbing Fixtures
ANSI A112.19.2	Vitreous China Plumbing Fixtures
ANSI A112.19.4	Porcelain Enameled Formed Steel Plumbing Fixtures
ANSI A112.19.5	Trim for Water-Closet Bowls, Tanks, and Urinals
ANSI Z124.2	Gel-Coated Glass-Fiber Reinforced Polyester Resin Shower Receptor and Shower Stall Units
ANSI Z358.1	Emergency Eye Wash and Shower Equipment
ASSE 1071	Performance Requirements for Temperature Actuated Mixing Valves for Plumbed Emergency Equipment
ARI 1010	Drinking Fountains and Self-Contained Mechanically Refrigerated Drinking Water Coolers

- B. Plumbing piping, fixtures, specialties, and equipment shall be:

1. Of the latest design.
2. All brass must be of the best quality. Lightweight goods will not be accepted.
3. Manufactured for the intended usage.
4. Compatible with elements of related or connected Work.

- C. Design Features

1. Plumbing fixtures shall be provided without flaws, and with a white finish unless otherwise indicated.
 2. Exposed brass, faucets, valves, wastes, traps, piping, and escutcheons shall be chrome plated. Faucets shall be free of tool marks or other flaws.
 3. "P" traps on lavatories and sinks shall be cast brass with cleanouts.
 4. Each fixture shall be provided with individual stops and shall be anchored firmly to the building wall or floor.
 5. Softeners, water heaters, and lab equipment shall be provided with drains and isolating valves on each side.
 6. For the purpose of establishing type and class of fixtures and faucets required, the following manufactures and models are indicated: Fixture manufacturers and model of equal features and quality may be submitted for approval.
 7. Refer to Architectural Drawings for mounting height and exact location of all plumbing fixtures. Handicapped fixtures shall be installed to meet the latest ADA requirements.
- D. Water closets, valves, fixtures, and hardware shall be approved by local governing authorities as low-flow items.
- E. Floor-mounted and tank-type water closets indicated (by "HC") for handicapped persons or located within a toilet stall indicated for handicapped persons shall conform to ADA requirements.
- F. Any pipe, plumbing fitting or fixture, solder, or flux used in the installation or repair of any public water system or any plumbing in a facility providing water for human consumption, shall be "lead free" except when necessary for the repair of leaded joints of cast iron pipes.
1. Lead free means not more than 0.2 percent lead when used with respect to solder and flux, not more than 8 percent when used with respect to pipes and pipe fittings, and not more than 4 percent with respect to plumbing fixtures.
- G. Pre-wrapped Insulation
1. Insulate exposed lavatories drain piping, hot/cold stops and supplies in accordance with the requirements of ADA and the International Building Code (IBC).
 2. The pre-wrapped insulation shall be easily removable, bacteria resistant, molded to piping and fixture configurations, closed cell vinyl assemblies.
 3. Fasteners shall be corrosion-resistant and reusable.
 4. Pre-wrapped insulation shall be Lav Guard as manufactured by Truebro, Inc., Pro-Wrap as manufactured by McGuire Manufacturing Co., or equal.

2.02 FIXTURE SCHEDULE

Drawing Callout	Fixture Type	Description
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PLUMBING FIXTURES

WC-01	Water Closet (wall-hung)	Water closet, with elongated wall-mounted, siphon jet bowl, designed to flush at 1.28 GPF, 1-1/2-inch top spud; conforming to ADA when mounting at approved height; solid white plastic open front seat; automatic flush valve and escutcheon; cast-iron wall-carrier (with 1-inch water supply connection). Accepted manufacturer: Kohler K-4325, Kingston
LAV-01	Lavatory (ADA compliant wall-hung)	Lavatory basin, vitreous china, wall-mount, with overflow, drilled for concealed, single-hole, size 20" (508 mm) x 27" (686 mm), complete with wall carrier; chrome-plated combination supply with angle stops and pop-up fitting with aerator; sensor faucet with thermostatic mixing valve, and a 1-1/4-inch, chrome-plated "P" trap with chrome-plated escutcheon. Code Standards: ASME A112.19.2/CSA B45.1 ADA ICC/ANSI A117.1 Acceptable manufacturer: Kohler, Model K-12638, Greenwich

2.03 WATER CLOSET (WALL MOUNTED – FLUSH VALVE TYPE)

A. General

1. Vitreous china: color white unless noted otherwise. Elongated bowl, direct-fed siphon jet action. 1-1/2 inch top spud for external flush valve. China bolt covers. Dimensions within ASME Standard A112.19.2 tolerances.
2. Water closet shall conform to the hydraulic performance requirements of ASME A112.19.2/CSA B45.1 and shall be design for 1.28 gpf and 1.6gpf.
3. Water closet shall be ADA compliant when mount at proper height.
4. Acceptable manufacturers:
 - a. Kohler, Model K-4325, Kingston
 - b. American Standard
 - c. Crane

B. Automatic Flush Valve (1.28 gpf)

1. Exposed Hardwired Automatic Sensor Flush Valve for Water Closets – Exposed, quiet diaphragm-type, chrome plated, flushometer valve with a polished exterior. Complete with a chloramine resistant, dual seal diaphragm with a clog resistant by-pass.
2. Valve shall be provided with 1" inlet, 1-1/2" outlet and 1.6 gallon per flush.
3. The valve is complete with high back pressure vacuum breaker, one piece hex coupling nut, adjustable tailpiece, spud coupling and flange for top spud connection. Control stop has internal siphon-guard protection. Internal seals are made of chloramine resistant materials.

4. The valve shall incorporate a motorized actuator, an integral infrared convergence-type proximity sensor and a manual push-button override into an all-metal, polished chrome plated housing. Valve actuator shall be ADA compliant.
5. Complete with hardwire 7.6 VDC power converter. Each power converter can accommodate up to eight flush valves., Zurn P6000-HW6 or equal.
6. Battery powered actuators are not acceptable.
7. Acceptable manufacturers:
 - a. Zurn, Model ZEMS6000-IS-WS1
 - b. Delany
 - c. Sloan

C. Wall Carrier

1. Fully compatible with water closet installation, adjustable, high extension (barrier free), cast iron frame with integral drain hub and vent, lugs for floor and wall attachment and threaded fixture studs.
2. The carrier shall conform to ASME A112.6.1M or ASME A112.6.2
3. Acceptable manufacturers:
 - a. J.R. Smith
 - b. Josam
 - c. Zurn

D. Seat

1. Open front, elongated, heavy duty injection molded white plastic, open front, extended back, hinged shall be self-sustaining with stainless steel fasteners, molded-in bumpers, without cover.
2. Seat shall comply with ANSI Z124.5 Toilet (Water Closet) Seats as a class Commercial Heavy Duty.
3. Acceptable manufacturers:
 - a. Bemis 1955SSCT
 - b. Church
 - c. Centoco

2.04 WALL MOUNTED LAVATORIES

A. General

1. Vitreous China Wall Hung Lavatory: ASME A112.19.2; vitreous china wall mount lavatory with overflow, with 4-inch high back, 21 x 18 inches with drillings on 4-inch centers.
2. Complete with concealed arm carrier and wall hanger.
3. Acceptable manufacturers:
 - a. Kohler, Model K-2032, Greenwich.
 - b. American Standard
 - c. Crane

B. Sensor Activated Faucet (0.5 gpf)

1. Chrome plated cast brass sensor faucet with motorized actuator, an integral infrared convergence-type proximity sensor with thirty second time out feature. Faucet shall be ADA compliant.
2. Furnish with 0.5 GPM aerator (complying with ANSI A112.18.1M Standard for flow).
3. Furnish with 4" centers cover plate.
4. Complete with hardwire 7.6 VDC power converter. Each power converter can accommodate up to eight valves., Zurn P6000-HW6 or equal.
 - a. Acceptable manufacturers:
 - b. Zurn, Model Z6913-F-CP4-XL
 - c. Meon
 - d. Sloan

C. ACCESSORIES

1. Chrome plated 17-gage brass P-trap with clean-out plug and arm with escutcheon.
2. Chrome plated rigid supplies to fixtures with supply stops, reducers, and escutcheons.
3. Offset waste with perforated open strainer.
4. Exposed piping, waste and supply, shall be insulated and offset to meet ADA compliance.

- D. Thermostatic mixing valve shall conform to ASSE 1070 and designed to be installed at the point of use. Zurn Model ZW1070XL or equal.

PART 3 -- EXECUTION

3.01 INSTALLATION

- A. Each fixture shall be installed with a trap that is easily removable for servicing and cleaning and vented in accordance with the applicable plumbing code.
- B. The Contractor shall provide chrome-plated rigid or flexible supplies to fixtures with angle stops, reducers, and escutcheons.
- C. Components shall be installed level and plumb, and supplies and wastes shall be centered on or between the wall tiles.
- D. Attachment
 - 1. Fixtures shall be installed and secured in place with wall supports, wall carriers, and bolts.
 - 2. Water closets shall be solidly attached to a floor or wall carrier with lag screws.
 - 3. Lead flashing shall not be used to hold fixtures in place.
- E. Sealant
 - 1. Fixtures shall be sealed to wall and floor surfaces with sealant in accordance with the requirements of Section 07 92 13 – Elastomeric Joint Sealants.
 - 2. Sealant color shall match the fixture.
- F. Fixtures shall be mounted to the following heights above finished floor:

Water Closet		
Standard	15 in (380 mm)	to top of bowl rim
Handicapped	17-19 in (430 - 480 mm)	to top of seat
Urinal		
Standard	22 in (560 mm)	to top of bowl rim
Handicapped	17 in (430 mm)	to top of bowl rim
Lavatory		
Standard	31 in (790 mm)	to top of basin rim
Handicapped	34 in (860 mm), max 29 in (740 mm), min	to top of basin rim clearance under or pullman option
Drinking Fountain		
Standard	40 in (1020)	mm to top of basin rim
Handicapped	36 in (920 mm), max 27 in (690 mm), min	to top of basin rim clearance under unit apron
Water Closet Flush Valves		
Standard	11 in (280 mm)	in. above bowl rim

Recessed	10 in (260 mm)	min. above bowl rim
Handicapped	44 in (1120 mm), max	in. above finished floor to flush valve control and easily accessible
Shower Heads		
Adult male	69.5 in (1770 mm)	to bottom of head
Adult female	64.5 in (1640 mm)	to bottom of head
Child	58.5 in (1490 mm)	to bottom of head
Handicapped	65 in (1650 mm), max	to outlet pipe
Handicapped Controls	48 in (1220 mm), max 38 in (970 mm), min	to top of controls to bottom of controls
Emergency Eye Wash		
Standard	38 in (970 mm)	to receptor rim
Handicapped	34 in (860 mm), max 27 in (690 mm)	to receptor rim to spray head
Emergency Shower		
Standard	84 in (2130 mm)	to bottom of head
Handicapped	48 in (1220 mm), max	to pull handle

3.02 ADJUSTING AND CLEANING

- A. Stops or valves shall be adjusted for the intended water flow rate to fixtures without splashing, noise, or overflow.
- B. At completion, the Contractor shall clean plumbing fixtures and equipment.

END OF SECTION

SECTION 23 05 00 – COMMON WORK RESULTS FOR HVAC

PART 1 -- GENERAL

1.01 SUMMARY

- A. The Contractor shall provide heating, ventilating, and air conditioning systems and associated equipment complete with supports, mounting frames, ventilators, ductwork, piping, louvers, panels, filters, grilles, electric drive units and controls, mechanical equipment, electrical work, appurtenances, testing, and balancing, as indicated in accordance with the Contract Documents.
- B. The equipment shall be installed ready for operation.

1.02 REFERENCE SPECIFICATIONS, CODES AND STANDARDS

A. Reference Specifications

01 33 00	Submittal Procedures
01 33 17	Structural Design, Support and Anchorage
01 42 19	Reference Standards
09 96 00	High-Performance Coatings
23 07 13	Duct Insulation
23 23 00	Refrigerant Piping
26 00 10	Electrical General Requirements
26 05 10	Electric Motors
26 05 15	Industrial Control Panels and Miscellaneous Devices
26 05 19	Wire and Cabling
26 05 33	Electrical Raceway Systems
26 05 43	Underground Raceways Systems
26 29 00	Low-Voltage Motor Control Centers
40 05 07	Hangers and Supports for Process Piping
40 05 23	Stainless Steel Process Pipe and Tubing

B. Reference Standards

Air Movement and Control Association International, Inc. (AMCA)	
American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE)	
ASHRAE Standard 52-76/ASHRAE Standard 52.1-1992	Gravimetric and Dust-Spot Procedures for Testing Air-Cleaning Devices Used in General Ventilation for Removing Particulate Matter
American Society of Civil Engineers (ASCE)	
ASCE 7-10	(2010; Errata 2011; Supp 1 2018) Minimum Design Loads and Associated Criteria for Buildings and Other Structures
American Society of Mechanical Engineers (ASME)	
Institute of Electrical and Electronics Engineers (IEEE)	

National Electrical Manufacturers Association (NEMA)	
National Fire Protection Association (NFPA)	
NFPA 72	(2022) National Fire Alarm and Signaling Code
NFPA 90A	(2021) Standard for the Installation of Air Conditioning and Ventilating Systems
Sheet Metal and Air Conditioning Contractors' National Association (SMACNA)	
Underwriters Laboratories (UL)	
UL 900	(2015) Standard for Air Filter Units

1.03 CONTRACTOR SUBMITTALS

A. Shop Drawings

1. Submit complete shop drawings and certificates, test reports, affidavits of compliance, for all equipment, ductwork and piping systems, in accordance with the requirements in Section 01 33 00 – Submittal Procedures, and as indicated in the individual equipment, piping or ductwork Sections.
2. Construction Drawings
 - a. The HVAC Drawings define the general layout, configuration, routing, size and the general intent of the design. and are not fabrication drawings.
 - b. The ductwork dimensions provided on the design drawings represent a free area and they are clear inside dimensions. The contractor shall be responsible to account for the loss of free area due acoustical lining, or any internal obstructions, and oversize the ductwork to provide the same free area as the one shown on the design drawings.
 - c. It shall be the Contactor's responsibility to develop the Shop Drawings required for the construction of the HVAC system.
3. The Shop Drawings shall include all necessary dimensions and details regarding equipment, pipe and ductwork joints, fittings, valves, appurtenances, design calculations, and material lists.
4. The submittals shall include detailed layout, spool, or fabrication drawings which shall show all fittings, and supports as necessary to accommodate the equipment as a complete and functional system.

B. Equipment Numbers

1. Equipment is identified by assigned numbers for reference and location purposes in the Contract Documents.
2. Indicate the appropriate equipment numbers on the Shop Drawings and other submittals.

C. Furnish certified fan curves for each fan.

1.04 WARRANTY

- A. Air conditioners, heaters, fans, ventilators, grilles, and the like, that are provided by the Contractor shall carry the manufacturer's standard warranty.
- B. Warranties shall be furnished to the Engineer upon final acceptance of the completed systems by the Owner.
- C. Refrigerant compressors shall carry a manufacturer's 5-year warranty.
- D. Control System
 - 1. The temperature and equipment control system shall be warranted free from defects in workmanship and material under normal use and service for a period of one year after acceptance by the Engineer.
 - 2. Equipment that proves to be defective in workmanship or material during the warranty period shall be adjusted, repaired, or replaced by the automatic control manufacturer as part of the Contract.

PART 2 -- PRODUCTS

2.01 GENERAL

- A. Quality
 - 1. Mechanisms and other parts shall be amply proportioned for the stresses which may occur during operation and for any other stresses which may occur during fabrication and erection.
 - 2. Individual parts furnished which are alike in all units shall be alike in workmanship, design, and materials, and shall be of the manufacturer's top-line, industrial-commercial grade.
- B. Supports
 - 1. Equipment and appurtenances shall be firmly anchored or connected to supporting members.
 - 2. Equipment shall be supported on restrained spring-type vibration isolators.
 - 3. Support as required for the proper installation of the equipment, but not forming an integral part of the building structure, shall be provided unless otherwise indicated.
- C. Noise and Vibration Control
 - 1. The system shall be free of objectionable vibrations and noise.
 - 2. Provide flexible connections in ducts and piping connections to fans, compressors, and other vibrating equipment.

2.02 MOTORS

- A. Motors provided with the equipment shall conform to the latest IEEE and NEMA requirements for mechanical and electrical characteristics, including service factors.

- B. Motors shall be in conformance with the requirements of Section 26 05 10 – Low-Voltage Electric Motors.
- C. Each motor shall bear the manufacturer's nameplate with complete motor data.
- D. Each motor shall be of ample size and construction to continuously carry the loads which might be imposed by the equipment throughout the full range of operation of the equipment.
- E. The maximum motor loading shall be less than or equal to the nameplate horsepower rating, exclusive of the service factor.

2.03 ELECTRICAL WORK

- A. The Work of this section shall include:
 - 1. Provide controls, sensors and control panels relating to the HVAC systems, including starters, thermostats, motorized dampers, louver operators and other equipment as indicated.
 - 2. Provide control wiring of 120-volt and less as indicated in this Section and in conformance the requirements of Division 26 – Electrical and Division 40 – Instrumentation and Control.
- B. The Work of Division 26 shall include:
 - 1. Provide local power disconnects, where required.
 - 2. Provide circuit breakers, starters in motor control centers, and 120-, 208-, 240- and 480-volt power feeders from the starters and circuit breakers to the HVAC equipment, as indicated.
- C. Stand-alone starters shall be in accordance with the requirements of Section 26 29 13.13 - Across-the-Line Motor Controllers.
- D. Starters in motor control centers shall be in accordance with the requirements of Section 26 24 19 - Motor Control Centers.
- E. Enclosures shall be of the same NEMA class as the electrical equipment in the same area.
- F. Starters shall be of the same manufacturer as the starters indicated under Section 26 29 13.13 – Across-the-Line Motor Controllers and 26 24 19 – Motor Control Centers.
- G. Low-voltage control wiring shall be in accordance with the National Electric Code.
- H. Control wiring for line voltage 120-volt and higher shall be in conformance with the requirements of Section 26 05 19 – Wire and Cabling.
- I. Control Panels shall be in conformance with the requirements of Section 26 05 15 – Industrial Control Panels and Miscellaneous Devices.
- J. Conduit shall be in conformance with the requirements of Section 26 05 33 – Raceway and Boxes for Electrical Systems and Section 26 05 43 – Underground Ducts and Raceways for Electrical Systems.

2.04 FLASHING

- A. Equipment that passes through roofs of buildings or structures shall be provided with flashing as indicated.
- B. Flashing shall be in conformance with the requirements of Section 07 42 00 – Metal Roof and Wall Panels.

2.05 PIPE AND FITTINGS

- A. Refrigerant piping shall be Type L hard temper copper with cast brass fittings.
- B. Provide a drain at each low point in the piping system.
- C. Copper pipe fittings shall be in conformance with the requirements of Section 23 23 00 – Refrigerant Piping.
- D. Joints in refrigeration piping shall be made with silver solder.

2.06 PIPING AND DUCTWORK INSULATION

- A. HVAC Ductwork insulation shall be in conformance with the requirements of Section 23 07 13 – HVAC Ductwork Insulation.
- B. HVAC Refrigerant Pipe insulation shall be in conformance with the requirements of Section 23 23 00 – Refrigerant Piping.

2.07 HANGERS AND SUPPORTS

- A. Anchorage and bracing for all suspended ductwork and other distribution systems needs to be provided per 2016 CBC Section 1613/ASCE 7-10 Chapter 13
- B. Provide all necessary hangers, supports, concrete inserts, anchors and guides for material and equipment to be installed.
- C. No perforated strap hangers and no wire supports will be accepted.
- D. Insulation Allowance
 - 1. Hangers supporting insulated pipe shall be sized to fit the pipe plus the insulation.
 - 2. The insulation at support points shall be provided with a metal shield in order to prevent damage to the insulation.
- E. Anchors and guides shall be constructed of steel, in accordance with approved Shop Drawings, and as indicated.
- F. Pipe hangers used to support uninsulated copper piping shall be copper plated.
- G. Anchors
 - 1. Anchorages shall be obtained by welding lugs onto the pipe and providing abutting surfaces against the lugs to restrict longitudinal movement.
 - 2. Anchors shall be designed such that the pipe may be removed by removing bolts; no welding of pipe to the anchor will be accepted.

COMMON WORK RESULTS FOR HVAC

- 3. bolting materials shall be cadmium plated.
- H. Guides shall be located not more than 20 ft from each expansion loop or joint.
- I. Horizontal runs of pipe shall be provided with supports spaced such that the sag of the unsupported length will not create any pockets in the piping (weight of fluid included).
- J. Pipe support lengths shall be in conformance with the requirements of Section 40 05 07 – Hangers and Supports for Process Piping.
- K. Vertical Piping
 - 1. Vertical piping shall be:
 - a. Supported at the base with fittings made for this purpose; or
 - b. Supported from the nearest horizontal member or floor with a riser extension pipe clamp.
 - 2. Provide a riser extension clamp on each floor.
- L. Hangers for ductwork and equipment shall be as indicated and in accordance with the guidelines of the Sheet Metal and Air Conditioning Contractors National Association (SMACNA).
- M. Inserts shall be galvanized.

2.08 PIPE SLEEVES

- A. The Contractor shall examine the Drawings carefully for sleeves that are to be built into the construction and plan the Work accordingly, such that the sleeves are placed well in advance and care is taken with their location and support until encased.
- B. Sleeves shall be fabricated from standard weight galvanized steel pipe for dry interior installations.
- C. Sleeves for exterior or wet installations shall be fabricated from standard-weight ductile black steel, stainless steel, or standard-weight PVC for pipe temperatures below 120 deg F .
- D. Sleeves shall be sized one pipe size larger than uninsulated piping and one pipe size larger than piping plus insulation for insulated pipe.
- E. Locations
 - 1. Where pipes pass through floors, sleeves shall extend 3-in above the finished floor.
 - 2. Where pipes pass through walls, sleeves shall be flush with the wall.

2.09 MOTORIZED DAMPERS

- A. General
 - 1. Provide motorized opposed blade dampers as indicated.

2. Damper sizes and capacities shall be as indicated on the Drawings.

B. Design and Construction

1. The damper and frames shall be fabricated from aluminum with a minimum thickness of B&S 12-gauge.
2. The aluminum blades shall be provided with interlocking edges, with one center and two edge crimps, and brass bearings.
3. The frame shall be of welded channel construction and shall be provided with lugs and mounting brackets for damper operators.
4. The dampers shall be provided with felt or rubber seals at their edges to minimize air infiltration when closed.

C. Motors

1. Damper motors shall be electric, with necessary linkages for positioning the damper blades.
2. The motors shall be powered open and spring-closed, unless otherwise indicated.

2.10 MANUAL VOLUME DAMPERS

A. General

1. Provide volume control dampers in accessible locations in branch supply ducts and at each exhaust air opening, in order to properly regulate the volume of air delivered or withdrawn from each inlet and outlet, and as indicated.
2. Damper sizes and capacities shall be as indicated on the Drawings.

B. Construction

1. The volume dampers shall be of the opposed blade type.
2. The dampers shall be constructed of aluminum, of B & S 14-gauge thickness.
3. The dampers shall be suitably reinforced with sturdy control shafts.
4. Ductwork shall be reinforced to double thickness at damper shaft openings.

C. No splitter dampers will be accepted.

D. Manual control dampers shall be provided with mechanisms for adjustment and locking into position after being set.

2.11 REGISTERS, GRILLES AND DIFFUSERS

A. General

1. Provide supply and return registers and grilles, and all supply diffusers as indicated.

2. The sizes, capacities, and deflection of each unit shall be as indicated on the Drawings.
- B. Registers, grilles and diffusers shall be constructed of aluminum.
- C. The finish shall be a white baked-on enamel.
- D. Accessory equipment shall be constructed of aluminum, or steel if aluminum is not available, and provided with a white baked-on enamel.
- E. The proper border style shall be selected by the Contractor to suit the installation conditions.
- F. Registers, grilles, and diffusers located in corrosive atmospheres, as indicated, shall be painted with a special protective coating in accordance with the requirements of Section 09 96 00 – High-Performance Coatings.

2.12 AIR FILTERS

- A. The aluminum washable metal mesh filter shall be 2-in thick and shall consist of multiple layers of 20-gauge aluminum slit and expanded into mesh of differing densities with hundreds of baffle-like surfaces. Filter shall contain 5 layers of 1/4-in and 5/8-in thick corrugated aluminum. Mesh media shall be contained within a .017-.019 one piece constructed roll formed aluminum frame. Frame shall come with drainage ports. Initial airflow resistance shall be 0.04-in w.g. initial resistance and 0.50-in w.g. recommended final resistance, and rated for maximum Temperature of 240 deg F.
 1. Aluminum Washable Air Filters Manufacturer, or Equal
 - a. Permatron, Model MMA-2-in
- B. Flat air filters shall be 2-in thick, pleated, throw-away type, and provided as an integral part of each unit. The flat air filters shall be constructed of an adhesive-coated fiber media, rated at 300 fpm face velocity; and rated at 0.04-in w.g. initial resistance and 0.50-in w.g. recommended final resistance.
 1. Flat Air Filters Manufacturer, or Equal
 - a. Airguard Industries
 - b. Farr Co.
 - c. Snyder General Corp.
- C. Filter Supply
 1. Furnish 3 complete spare filter changes for each flat filter in each unit.
 2. Provide one new filter set in each unit at the time of turning the units over to the Owner.
 3. Filters used in the units during construction are not included in the above supply, and these filters shall be provided as part of the Work.

2.13 ROOF CURBS AND ROOF EQUIPMENT SUPPORTS

A. Curbs

1. Roof curbs for all roof openings for roof mounted exhaust fans and air intakes and exhausts, unless otherwise indicated, shall be of the raised cant type with a minimum 12-in height above the roof line.
2. The curbs shall be pitched at the base for roof pitches in excess of 3/8-in per foot.
3. Provide a minimum 4-in raised cant unless otherwise indicated.
4. The curbs shall be of a box design, constructed from 20-gauge galvanized steel with continuous welded seams, full mitered angle seam corners, and factory-installed wood Nailers.
5. Insulate the curbs with a minimum of 1 ½-in thick, 3 lbs. per cu.ft. density rigid board fiberglass.
6. Roof curbs shall be provided with an 18-gauge stainless steel liner set in mastic and extended the full height of curb if the duct does not extend to the top of the curb.
7. The roof curbs shall be supplied by the manufacturer of the equipment being provided.
8. Roof Curb Manufacturers, or Equal
 - a. Pate Model PC-5
 - b. Thy curb

B. Equipment Supports

1. Provide roof equipment supports for roof-mounted equipment.
2. Construct the supports from 180 gauge galvanized steel, with continuous welded seams, an integral base plate, a wood nailer with a 1-in overhang to accommodate insulation, and counter flashing with lag screws.
3. Provide the supports with a raised cant of not less than 4-in and a minimum of 15-in high.
4. The length and width of the units shall conform to the support requirements of the equipment being supported.
5. Roof Equipment Supports Manufacturers, or Equal
 - a. Pate Model PC-5
 - b. Thycurb

2.14 PAINTING

- A. Painting of the equipment and materials shall comply with the requirements of Section 09 96 00 – High-Performance Coatings.
- B. Touch-Ups
 - 1. Touch up factory-painted surfaces that are rusted or scratched.
- C. Clean finishes to be touched up to bright metal, prime with a corrosion inhibitor, and finish with a coating to match the original finish.

PART 3 -- EXECUTION

3.01 GENERAL

- A. Openings - New Construction
 - 1. Provide necessary openings in walls, floors, and roofs for the passage of heating and ventilating equipment in the buildings.
 - 2. Openings shall be as indicated or as required to provide passage for heating and ventilating Work.
 - 3. Provide hanger and support inserts into masonry or structural steel as required for proper completion of the Work.
- B. Openings - Existing Construction
 - 1. Provide openings required in the existing construction for piping and equipment that are not specifically indicated.
 - 2. Openings shall be cut in a neat and orderly manner with as little damage to existing structures as possible.
 - 3. The patching of openings that have been cut shall match the existing construction.
 - 4. Provide hangers and supporting members installed in the existing masonry or structural steel as required for proper completion of the Work.

3.02 INSTALLATION OF PIPING

- A. Condensate Drain Piping
 - 1. Provide piping system for all HVAC equipment producing condensate from a cooling coil. Fabricate from type-L copper tube with solder-joint fittings.
 - 2. Each unit shall have a primary and secondary means of discharging condensate to an approved receptacle. A drain pan water level sensor is an acceptable alternate to a secondary drain.
 - 3. Slope drain piping away from equipment for positive drainage and provide clean-outs at abrupt changes in direction.

4. Route condensate drain piping as shown on plans. Do not route piping above electrical or process equipment or panels.

3.03 TESTING AND BALANCING

A. Balancing Subcontractor

1. After the installation Work has been completed, the Contractor shall provide the services of an independent balancing subcontractor who shall perform necessary adjustments of volume dampers, supply fans, and exhaust fans.

B. Balancing Procedures

1. Balancing and testing shall be in conformance with the requirements of Section 23 05 93 – Testing, Adjusting, and Balancing for HVAC.

3.04 VIBRATION ISOLATORS

- A. Install isolation equipment in strict compliance with the manufacturer's recommendations.

3.05 TEMPERATURE AND EQUIPMENT CONTROL

- A. After completion of the installation, use trained personnel to adjust thermostats, and sensors in the motors and other provided equipment, and place them in complete operating condition subject to the approval of the Engineer.
- B. Instruct the operating personnel in the operation of the control system.

END OF SECTION

SECTION 23 05 93 – TESTING, ADJUSTING, AND BALANCING FOR HVAC

PART 1 -- GENERAL

- A. The Work included in this Section shall consist of the furnishing of all labor, instruments, tools, and services as required for the total system balancing of the heating, ventilating, and air conditioning (HVAC) systems as indicated in the Contract Documents.
- B. The Work under this Section shall include the following items:
 - 1. Preparation for balancing of air systems
 - 2. Preparation of control systems
 - 3. Notification requirements by the General Contractor of systems readiness

1.02 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

A. Reference Standards

Associated Air Balance Council (AABC)	
American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE)	
ASTM International (ASTM)	
American National Standards Institute (ANSI)	
ANSI S1.13	(2020) American National Standard Measurement of Sound Pressure Levels in Air

PART 2 -- PRODUCTS (NOT USED)

PART 3 -- EXECUTION

3.01 GENERAL

- A. Testing, adjusting, and balancing (TAB) of the air conditioning systems and related ancillary equipment shall be performed by a certified, independent third-party, AABC Agency, selected and employed by the Contractor and approved by the Owner.
- B. The preparation for and corrections necessary for the testing, adjusting, and balancing of these systems, as described herein, are the responsibility of the Contractor.
- C. Make changes or replacements to fan sheaves and belts, dampers, valves, and the like, as may be required for correct balance as advised by the TAB firm, as part of the Work.
- D. Provide and coordinate the services of qualified, responsible subcontractors, suppliers, and personnel, as required to correct, repair, or replace deficient items or conditions found during the course of the Project, including the testing, adjusting, and balancing period.
- E. Operate the systems for the length of time necessary to properly verify their completion and readiness for TAB.

F. Scheduling

1. Project completion schedules shall allow for sufficient time to permit the completion of TAB services prior to Owner occupancy.
2. Allow adequate time for coordinating Owner-required services associated with the testing and balancing activities during the construction period and prior to Substantial Completion.

G. Accessibility

1. Install valves, dampers, and miscellaneous adjustment devices in a manner that will leave them accessible and readily adjustable.
2. Should any such device not be readily accessible, provide access as requested by the TAB firm.
3. Malfunctions encountered by TAB personnel and reported to the Contractor shall be corrected by the Contractor immediately such that the balancing work can proceed with minimal delays.

H. The TAB firm shall check, adjust, and balance the components of the HVAC system in order to obtain the optimal performance of the equipment.

I. The Work is intended to be accomplished after the system components are installed and operating as indicated and required.

J. It shall be the responsibility of the Contractor to place the equipment into service.

K. The following components of the HVAC systems shall be tested, adjusted, and balanced:

1. Air moving equipment
2. Air distribution systems
3. Heating and cooling systems
4. Control systems (testing and verification)

3.02 FIELD TESTING

- A. During the progress of the work, tests shall be performed as indicated and as required by authorities having jurisdiction, including the local building department, the Owner, the Owner's insuring agency, and the Engineer.
- B. Perform such tests as part of the Work, including qualified personnel, equipment apparatus, additional thermometer wells, gauge connections, instrument connections, and services as required to perform the tests.
- C. Submit 1 copies of each complete test report to the Engineer for review and send 2 copies of the accepted report to the Owner.

3.03 DEFECTIVE WORK

- A. Leaks, damage, and defects discovered or resulting from tests shall be repaired or replaced to a like-new condition.
- B. Leaky pipe joints, ductwork, and the like, shall be removed and replaced with acceptable materials.
- C. Reporting
 - 1. During the balancing process, as abnormalities and malfunctions of equipment or components are discovered by the TAB personnel, the TAB firm shall advise the Engineer and Owner in writing such that the conditions may be corrected by the Contractor.
 - 2. The written document need not be formal but must be understandable and legible.
 - 3. The TAB firm shall not instructor direct subcontractors in any of the Work.

3.04 CONTRACTOR'S RESPONSIBILITIES

- A. Have the building and air conditioning systems in complete operational readiness for the TAB Work to begin.
- B. Allow sufficient time for the TAB firm to perform their Work within the construction schedule.
- C. Complete the W by systems or floors, whichever is the more efficient method for testing systems.
- D. Scheduling
 - 1. Within 2 weeks after the construction schedule has been developed, schedule a TAB coordination meeting to include the TAB firm, the Contractor and primary subcontractors, the Engineer, and the Owner, for the purpose of developing a testing schedule for the Project.
 - 2. Submit copies of the proposed schedule to the TAB firm at least one week prior to the coordination meeting.
- E. Promptly correct deficiencies of materials and workmanship identified as delaying completion of the TAB firm's Work.
- F. Assume responsibility for added costs to the Owner resulting from failure to have the building and air conditioning systems ready for TAB when scheduled, and from failure to correct deficiencies promptly.
- G. Coordinate with the TAB firm to compile and submit:
 - 1. One set of HVAC specifications
 - 2. One copy of relevant revisions, clarifications, and modifications
 - 3. One complete set of Drawings, less the Civil and Structural sheets

4. One set of the HVAC floor plans of the conditioned spaces
5. One copy of approved submittal data for installed equipment
6. One copy of related changes as required to accomplish the indicated test procedures

3.05 TAB FIRM RESPONSIBILITIES

A. The following observations and tests shall be performed by the TAB firm:

1. During the construction submittal stage and before the submittal documents are finalized, review the mechanical and HVAC submittals, drawings and specifications for balance-ability and furnish commentary.
2. During construction, review approved HVAC submittals such as control diagrams, air handling devices, and the like, that pertain to TAB work and balancing.
3. Perform construction observations and submit a written report including the following topics.
 - a. The ductwork prior to insulation and ceiling cover-up
4. Perform a pre-balance site review and submit a written report.

3.06 OPERATIONAL READINESS

- A. "Operational readiness," as referred to in this Section, shall be defined as the time when the construction status of the building permits the closing of doors, windows, ceilings, and the like, to obtain simulated or projected operating conditions.
- B. Operational readiness of the HVAC system shall require that the following items have been accomplished:
1. Air Distribution Systems
 - a. The installation conforms to the indicated design requirements.
 - b. Volume, smoke, and smoke/fire dampers have been properly located and are functional.
 - c. Dampers have tight closure and open fully with smooth and free operation.
 - d. Supply, return, exhaust, and transfer grilles, registers, diffusers, and terminal devices have been installed and secured in a fully open position.
 - e. Air handling systems, units, and associated apparatus, such as heating and cooling coils, filter sections, access doors, and the like, have been sealed to eliminate uncontrolled bypass or leakage of air.
 - f. Final clean filters are in place, coils are clean with fins straightened, bearings are properly greased, belts are aligned and tightened, and the system is completely operational.

- g. It has been verified that all systems are operating within the design pressure limits of the piping and ductwork.
- h. Fans (supply, return, and exhaust) are operating and verified for freedom from vibration, proper fan rotation and belt tension.
- i. Heater elements in motor starters are of proper size and rating, in accordance with the starter manufacturer's requirements.
- j. Motor amperage and voltage have been recorded on each phase at start-up and verified that they do not exceed nameplate ratings.

2. Automatic Controls

- a. A meeting has been held with the Engineer, the TAB firm, and the Owner, for a pre-submittal review of the proposed controls strategy.
- b. Control components have been installed in accordance with project requirements and are functional, including electrical interlocks, damper sequences, air and water resets, fire and freeze stats, high- and low-temperature thermostats, safeties, and the like.
- c. Controlling instruments have been calibrated and set for design operating conditions, with the exception of components that require input from the TAB firm, but a default has been set.
 - 1) Cooperate with the TAB firm and provide all software and interfaces to communicate with the system.
- d. Controls, sensors, operators, sequences, and the like, have been checked before notifying the TAB firm that the Energy Management System is operational.
 - 1) Furnish technical support (technicians and necessary computers) for a complete check of these systems.
- e. A start-up report has been submitted.
 - 1) The start-up report shall include the submitted and actual RPM, and the actual and nameplate voltage and amperage of all motors.
 - 2) This requirement applies to each piece of electrically driven air conditioning equipment in the system, including supply and exhaust fans, other fans of fractional horsepower, pumps, and the like.
 - 3) Furnish the addresses and initial set points of all controlled devices.

3.07 NOTIFICATION OF SYSTEM READINESS

- A. After the above operational readiness items have been accomplished, notify the Engineer in writing, certifying that the Work has been accomplished and that the building and the air conditioning systems are in operational readiness for testing, adjusting, and balancing.
- B. With the notification, include a copy of tabulated data as required.

- C. The Engineer will notify the TAB firm of the readiness for balancing, and forward copies of the Contractor's certification and tabulated motor voltages, currents, and RPM.
- D. If the TAB firm has been notified as described above and the inspection reveals that the TAB services notification is premature, costs of the inspection and wasted work accomplished by the TAB firm shall be reimbursed to the appropriate parties by the Contractor.

3.08 TESTING AND BALANCING

- A. In coordination with the TAB firm, submit an overview of system TAB procedures including:
 - 1. An agenda
 - 2. Field observation reports
 - 3. System testing, including:
 - a. Traverses to be made
 - b. Instrumentation to be used
 - c. How correction factors for grilles and diffusers will be obtained
 - d. How measurements will be verified at maximum and minimum
 - e. How control components will be verified
 - 4. Report forms with each systems components identified and numbered.

3.09 INSTRUMENTATION

- A. Ensure that instruments being used are currently calibrated and listed in the TAB report, showing instrument description, serial number, and date of calibration.
- B. The accuracy of instruments used shall be as indicated in the current AABC National Standards.

3.10 FINAL AIR BALANCE

- A. When systems are complete and ready for operation, the TAB firm shall perform a final air balance for all air systems and record the results.
- B. The volume of air for the supply, return, exhaust, and outside air equipment and terminals shall be tested and balanced within the tolerances of the AABC Standard.
- C. Air handling unit and fan volumes shall be adjusted by changing fan speed.
- D. Air distribution device volume shall be adjusted using the spin-in damper for flexible duct-connected devices, and the damper for duct-connected devices.
- E. Air distribution devices shall be balanced with air patterns as indicated.
- F. Duct volume dampers shall be adjusted to provide air volume to branch ducts where such dampers are indicated.

G. The general scope of balancing by the TAB firm shall include the following items:

1. Filters: Check air filters and filter media and balance only systems with essentially clean filters and filter media.
2. Fan Speed: Measure and record RPM at each fan speed.
3. Voltage and Amperage Readings: Measure and record the final operating amperages and voltage for each motor.
4. Static Pressure Profile
 - a. Static pressure profiles shall be measured and recorded across each supply fan, cooling coil, heating coil, return air fan, air handling unit filter, and exhaust fan, and at the furthest air device or terminal unit from the air handler supplying that device.
 - b. Furnish static pressure profiles for systems which do not perform as designed.
5. Equipment Air Flow: Adjust and record exhaust, return, outside, and supply air CFM and temperatures, as applicable, at each fan.
6. Outlet Air Flow
 - a. Adjust each exhaust inlet and supply diffuser, register and grille to within the tolerances shown in the AABC Standard.
 - b. Include all terminal points of air supply and all points of exhaust.
7. Pitot Tube Traverses
 - a. For use in future troubleshooting by maintenance personnel, measure air velocity in all exhaust ducts, main supply ducts, outside air, and return ducts, and record by the Pitot tube traverse method shown in the AABC Standard.
 - b. Locations of these traverse test stations shall be described both verbally and by graphic representation on the sheet containing the data.

3.11 SOUND

- A. Read and record sound levels at up to 15 locations in the building designated by the Engineer, and show that all areas are within acceptable sound levels in accordance with ASTM and ASHRAE Standard Test method for measurement of sound in commercial Spaces, or the American National Standard Institute's Methods for the Measurement of Sound Pressure Levels, ANSI S1.13.
- B. Perform measurements using an octave band analyzer.
- C. Conduct the tests when the building is quiet.

3.12 TESTING OF TEMPERATURE CONTROL SYSTEMS

- A. Coordinate with the Contractor in order to ensure that the most effective total system operation is within the design limitations, and to obtain a mutual understanding of the intended control performance.

- B. Verify that all control devices are properly connected and operated by the intended controller.
- C. Observe that all valves are properly installed in the piping system in relation to direction of flow and location.
- D. Observe the calibration of all controllers.
- E. Verify the proper application of all normally opened and normally closed valves.
- F. Sensors
 - 1. Observe the locations of all sensors in order to verify whether their position will allow them to sense the intended temperatures and pressures of the media accurately.
 - 2. The Contractor shall relocate the sensors as deemed necessary by the TAB firm.
 - a. Verify that the sequence of operation for control modes is in accordance with approved Shop Drawings and as indicated.
 - b. Verify the proper operation of all interlock systems.

END OF SECTION

SECTION 23 09 01 – INSTRUMENTATION AND CONTROL FOR HVAC (STAND ALONE SYSTEM)

PART 1 -- GENERAL

1.01 PRODUCTS FURNISHED AND INSTALLED UNDER THIS SECTION

A. Section 23 - Refrigerant Piping - The HVAC Subcontractor shall:

1. Furnish and install all pressure and temperature sensor wells and sockets, which are specified to be supplied by this Section.

B. Section 23 - Ductwork Accessories - The HVAC Subcontractor shall:

1. Furnish and install all duct smoke detectors whether shown on the drawings or required by code. If the project includes an existing fire alarm panel all signals from the duct smoke detectors shall be transmitted to the existing fire alarm panel. If the project does not include an existing fire alarm panel, and a new fire alarm panel is not required for any other reason, signals from the duct smoke detectors shall be transmitted to the HVAC automatic temperature control panel.
2. Furnish and install all automatic dampers and provide necessary blank off plates or transitions required to install dampers that are smaller than duct size.
3. Assemble multiple section dampers with required interconnecting and jackshaft linkage and extend required number of shafts through duct for external mounting of damper motors.
4. Furnish and install all necessary sheet metal baffle plates to eliminate stratification and provide the air volumes specified. Locate baffles by experimentation. Fix and seal permanently in place only after stratification problems have been eliminated.
5. Furnish and install airflow stations specified under this Section.
6. Furnish and install access doors or other approved means of access through ducts for service to control equipment.

C. Section 26 Electrical - The Electrical Subcontractor shall:

1. Furnish and install and connect all power wiring. Power wiring shall be defined as:
 - a. Wiring of all power feeds through all disconnect starters and variable speed controllers to electric motors.
 - b. Provide local power disconnects, where required.
 - c. Provide circuit breakers, starters in motor control centers, and 120-, 208-, 240- and 480-volt power feeders from the starters and circuit breakers to the HVAC equipment, as indicated.
 - d. Wiring of 120 VAC normal/emergency power feeds to all temperature control panels.
 - e. Power wiring to 120/277-volt single-phase motors shown on electrical plans and all VAV boxes shown (with or without fan motors).

- f. All conduit, wiring and terminations between the ATC Panel and the Facility SCADA System

D. Section 23 Electrical - The HVAC Subcontractor shall:

1. Design and install a complete HVAC controls system as described herein and contract drawings.
 2. Provide controls, sensors and control panels relating to the HVAC systems, including starters, thermostats, duct smoke detectors, motorized dampers, louver operators and other equipment as indicated.
 3. Provide control wiring of 120-volt and less as indicated in this Section and in conformance the requirements of Division 26 – Electrical and Division 40 – Instrumentation and Control.
- E. Starters, whether as an integral or separate part of the equipment, shall be in accordance with the requirements of Section 26 24 19 – Motor Control Centers.
- F. Enclosures shall be of the same NEMA class as the electrical equipment in the same area.
- G. Starters shall be of the same manufacturer as the starters indicated under Section 26 24 19 – Motor Control Centers.
- H. Low-voltage control wiring shall be in accordance with the National Electric Code.
- I. Control wiring for line voltage 120-volt and higher shall be in conformance with the requirements of Division 26.
- J. Control Panels shall be in conformance with the requirements of Section 26 27 16 - Electrical Cabinets and Enclosures.
- K. Conduit shall be in conformance with the requirements of Section 26 05 33 – Raceway and Boxes for Electrical Systems and Section 26 05 43 – Underground Ducts and Raceways for Electrical Systems.

1.02 RELATED SECTIONS

- A. The General Conditions of the Contract, Supplementary Conditions, and General Requirements are a part of this Specification and shall be used in conjunction with this Section as a part of the contract documents. Consult them for further instructions pertaining to this Work. The Contractor is bound by the provisions of Division 0 and Division 1.
- B. The following Sections constitute related Work:

01 33 00	Submittal Procedures
23 05 00	Common Work Results for HVAC
26 05 20	Low-Voltage Electrical Power and Control Conductors and Cables
26 05 33	Raceway and Boxes for Electrical Systems
26 05 43	Underground Ducts and Raceways for Electrical Systems

26 24 19	Motor Control Centers
26 27 16	Electrical Cabinets and Enclosures
40 67 00	Control Panels

C. Reference Standards

1. All Work, materials, and equipment shall comply with the rules and regulations of all codes and ordinances of the local, state, and federal authorities having jurisdiction.
2. Such codes, when more restrictive, shall take precedence over the Contract Documents.

D. The installation shall comply with the following codes:

American National Standards Institute (ANSI)	
American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE)	
ASHRAE Standard 135	A Data Communication Protocol for Building Automation and Control Networks
ASHRAE/ANSI	135-2001: Data Communication Protocol for Building Automation and Control Systems (BACNET)
International Building Code (IBC)	
International Mechanical Code (IMC)	
National Electric Code (NEC)	
National Electrical Manufacturers Association (NEMA)	
National Fire Protection Association (NFPA)	
NFPA 72	National Fire Alarm and Signaling Code
Underwriters Laboratories (UL)	

1. All BAS DDC controllers and local user displays shall be UL-listed under Standard UL 916, category PAZX and Standard ULC C100, category UUKL7.
2. All electronic equipment shall conform to the requirements of FCC Regulation, Part 15, Governing Radio Frequency Electromagnetic Interference and labeled as such.

1.03 SYSTEM DESCRIPTION

A. Performance Standards

1. The system shall conform to the minimum standards indicated in Tables 1 and 2, below.
2. Information transmission and display times shall be based upon network, rather than modem, connections.
3. Programmable controllers shall be capable of executing DDC PID control loops at a selectable frequency adjustable down to once per second.

4. The Contractor shall be responsible for selecting execution times consistent with the mechanical process under control.
5. The system shall report all values with end-to-end accuracy as listed or better than those listed in Table 1.
6. Control loops shall maintain measured variable at set point within the tolerances listed in Table 2.

TABLE 1 - REPORTING ACCURACY

MEASURED VARIABLE	REPORTED ACCURACY
Space Temperature	plus or minus 1 deg F
Ducted Air	plus or minus 1 deg F
Outside Air	plus or minus 2 deg F
Dew Point	plus or minus 3 deg F
Water Temperature	plus or minus 1 deg F
Delta-T	plus or minus 0.25 deg F
Relative Humidity	plus or minus 5 percent RH
Water Flow	plus or minus 5 percent of full scale
Airflow (terminal)	plus or minus 10 percent of full scale (see Note 1)
Airflow (measuring stations)	plus or minus 5 percent of full scale
Airflow (pressurized spaces)	plus or minus 3 percent of full scale
Air Pressure (ducts)	plus or minus 0.1-in w.g.
Air Pressure (space)	plus or minus 0.01-in w.g.
Water Pressure	plus or minus 2 percent of full scale (see Note 2)
Electrical (A, V, W, Power Factor)	5 percent of reading (see Note 3)
Carbon Monoxide (CO)	plus or minus 5 percent of reading
Carbon Dioxide (CO2)	plus or minus 50 ppm

Note 1: 10 percent to 100 percent of full scale

Note 2: for both absolute and differential pressure

Note 3: not including utility-supplied meters

TABLE 2 - CONTROL STABILITY AND ACCURACY

CONTROLLED VARIABLE	CONTROL ACCURACY	RANGE OF MEDIUM
Airflow	plus or minus 10 percent of full scale	-----
Space Temperature	plus or minus 2 deg F	-----
Duct Temperature	plus or minus 3 deg F	-----
Humidity	plus or minus 5 percent RH	-----

1.04 SUBMITTALS

- A. Furnish submittals in accordance with the requirements of Section 01 33 00 – Submittal Procedures.

B. No Work may begin on any segment of the Project until submittals have been successfully reviewed for conformity with the design intent.

C. Submittals shall include:

1. Direct Digital Control System Hardware

- a. A complete bill of materials of equipment to be used, indicating quantity, manufacturer, model number, and other relevant technical data.
- b. Manufacturer's description and technical data, such as performance curves, product specification sheets, and installation and maintenance instructions for the following items and other relevant items not listed:

1) Direct Digital Controller (controller panels)

2) Transducers/Transmitters

3) Sensors (including accuracy data)

4) Actuators

5) Relays/Switches

6) Control Panels

7) Power Supply

8) Batteries

9) Wiring

2. Wiring diagrams and layouts for each control panel, showing all termination numbers.

3. Schematic diagrams for all field sensors and controllers, and floor plans of all sensor locations and control hardware.

4. Diagrams

- a. Submit schematic diagrams for all control, communication, and power wiring.
- b. Submit a schematic drawing of the central system installation. Show all interface wiring to the control system.
- c. Submit riser diagrams of wiring between central control unit and all control panels.

D. Controlled Systems

1. Schematic Diagrams

- a. Submit a schematic diagram of each controlled system.
- b. Indicate all control points labeled, with point names shown or listed.

- c. Graphically show the location of all control elements in the system.
- 2. Schematic Wiring Diagrams
 - a. Submit a schematic wiring diagram for each controlled system.
 - b. Label all elements.
 - c. Where a control element is the same as that shown on the control system schematic, it shall be labeled with the same name.
 - d. Label all terminals.
- 3. Instrument List
 - a. Submit an instrumentation list for each controlled system.
 - b. Each element of the controlled system shall be listed in table format.
 - c. The table shall show element name, type of device, manufacturer, model number, and product data sheet number.
- 4. Description
 - a. A complete description of the operation of the control system, including sequences of operation.
 - b. Include and reference a schematic diagram of the controlled system.
- 5. I/O
 - a. Submit a points list for each system controller, including both inputs and outputs (I/O), point number, the controlled device associated with the I/O point, and the location of the I/O device.
- 6. Quantities of items submitted will be reviewed but this shall be the responsibility of the Contractor.

1.05 QUALITY ASSURANCE

- A. All products used in this project installation shall be new and currently under manufacture and shall be the version currently being sold by the manufacturer for use in new installations.
- B. This installation shall not be used as a test site for any new products unless explicitly approved by the Owner in writing. Spare parts shall be available for at least five years after completion of this contract.

1.06 WARRANTY

- A. Labor and materials for the control system specified shall be warranted free from defects for a period of 12 months after final completion and Owner receives beneficial use of the system.

- B. Control system failures during the warranty period shall be adjusted, repaired, or replaced at no additional cost or reduction in service to the Owner.
- C. The Contractor shall respond to the Owner's request for warranty service within 24 hours during normal business hours.
- D. All Work shall have a single warranty date, even when the Owner has received beneficial use due to an early system start-up.
- E. If the Work specified is split into multiple contracts or a multi-phase contract, then each contract or phase shall have a separate warranty start date and period.

PART 2 -- PRODUCTS

2.01 GENERAL

A. Temperature Controls

1. Temperature Control Panels furnished and installed by the HVAC Subcontractor shall be in accordance with Section 26 27 16 - Electrical Cabinets and Enclosures. Temperature Control Panels provided by HVAC equipment manufacturers shall be in accordance with Section 40 67 00 - Control Panels.
2. The temperature control system shall be as indicated on contract documents and shall consist of DDC controllers.
3. HVAC Subcontractor shall be responsible for the installation, calibration, and operator training as necessary for a complete and full operating temperature control system.
4. The temperature control system shall be a complete stand-alone building automation system, modular in construction and not requiring a central computer for operation or programming.
5. All programming shall be possible from a keypad/display on any field panel or from a remote computer.
6. Systems which do not have a keypad/display capability shall be provided with a portable interface with required cables and software.

B. BAS Components

1. The basic elements of the Building Automation System (BAS) structure shall be built from only standard components kept in inventory by the BAS supplier.
2. The components shall not require customizing other than setting jumpers and switches, and adding firmware modules, software modules or software programming to perform required functions.
3. The BAS shall possess a fully modular architecture, permitting expansion through the addition of more DDCP units, sensors, actuators, and operator terminals.
4. Expansion beyond this must be able to be accomplished in additional panels or expansion modules without abandoning any initial equipment.

C. Direct Digital Control Panel

1. The Direct Digital Control Panel's (DDCP's) software shall include a complete operating system, control algorithm application packages, and a complete custom control, calculation application package to accomplish the indicated sequence of operation.
2. In addition to pre-programmed package software, DDCP controllers shall be provided with field-flexible programming capabilities without the use of external equipment such as EPROM programmers in order to meet the indicated requirements.
3. Each DDCP shall be capable of performing all specified control functions in a completely independent manner.
4. Each DDCP unit shall be capable of sharing point information with other such units, such that control sequences or control loops executed at one control unit may receive input signals from sensors connected to other units within the network.

D. Programming

1. Control software shall utilize "block" programming techniques connecting tested control blocks to form control sequencing.
2. Line-by-line programming requiring complete definition will not be accepted as a programming technique.
3. The programmer shall fill in the control parameters for each block to perform the required control sequence.

2.02 CONTROLLER SOFTWARE

- A. Each intelligent field panel shall be completely user programmable and shall include the indicated programs installed in the base operating system.

B. Alarms

1. The alarm program shall provide for alarm reporting as follows:
 - a. Pilot light indication at local ATC Panel
 - b. Remote annunciation of identified alarm to facility SCADA System via hardwired contact closure

C. Analog Input Scaling

1. Analog inputs shall be scaled and labeled to read out in engineering units of the variable being measured (e.g., deg, CFM, etc.).

D. Analog Outputs

1. Each analog output shall be user programmable to be direct or reverse acting and vary the output between 2 and 10 VDC.

2. The panel shall allow the user to program minimum and maximum output levels as well as a manual fixed output level.
3. The analog output shall be assignable to operate based on any physical input or calculated value on the network.

E. System Calendar

1. Each panel other than Application Specific Controllers (such as Terminal Controllers) shall be provided with a 365/366 day battery-backed clock, with an automatic daylight savings time switch-over on the day entered.

F. PID Control

1. In order to provide precise control, each analog output shall be programmable with a proportional plus integral plus derivative (PID) program.
2. Individual constants shall be programmable for the P, I, and D functions.
3. The integral time interval shall be user programmable.
4. The current proportional term, the integral term, and the PID sum shall be dynamically displayed on the screen to provide assistance to start-up and service personnel in tuning the system.

G. The diagnostics program in each panel shall monitor and report system status.

2.03 BUILDING CONTROLLERS

A. General

1. Provide an adequate number of Building Controllers to achieve the indicated performance.
2. Each controller shall meet the following requirements.
 - a. The Building Controller shall be provided with sufficient memory to support its operating system, database, and programming requirements.
 - b. Controllers that perform scheduling shall be provided with a real-time clock.

B. Communication

1. The Building Controller shall be provided with a service communication port for connection to a portable operator terminal.

C. Environment

1. Building Controller hardware shall be suitable for the anticipated ambient conditions.
2. Controllers used outdoors or in wet ambient conditions shall be mounted within waterproof enclosures, and shall be rated for operation at minus 40 deg F to plus 150 deg F.

3. Controllers used in conditioned space shall be mounted in dust-protective enclosures and shall be rated for operation at 32 deg F to 120 deg F.

D. Keypad

1. Provide a local keypad and display or a connection for a portable operator terminal for each Building Controller.
2. The keypad shall be provided for interrogating and editing data.
3. An optional system security password shall be available to prevent unauthorized use of the keypad and display.
4. If the manufacturer does not provide this keypad and display, provide a portable operator terminal.

E. Serviceability

1. Provide diagnostic LEDs for power, communication, and processor.
2. All wiring connections shall be made to field-removable, modular terminal strips or to a termination card connected by a ribbon cable.

F. Memory

1. The Building Controller shall maintain all BIOS and programming information in the event of a power loss for at least 72 hours.
2. Applications shall be maintained in flash memory.

G. Immunity to Power and Noise

1. The controller shall operate at 90 percent to 110 percent of its nominal voltage rating, and shall perform an orderly shutdown below 80 percent nominal voltage.
2. Operation shall be protected against electrical noise of 5 to 120 Hz and from keyed radios up to 5 W at 3 ft.

2.04 INPUT/OUTPUT INTERFACE

- A. Hardwired inputs and outputs may tie into the system through building controllers, advanced application controllers, or application-specific controllers.
- B. Input points and output points shall be protected such that shorting of the point to itself, to another point, or to ground will cause no damage to the controller.
- C. All input and output points shall be protected from voltage up to 24 V of any duration, such that contact with this voltage will cause no damage to the controller.
- D. Binary Inputs
 1. Provide binary inputs to allow the monitoring of ON-OFF signals from remote devices.

2. The binary inputs shall provide a wetting current of at least 12 mA in order to be compatible with commonly available control devices and shall be protected against the effects of contact bounce and noise.
3. Binary inputs shall sense “dry contact” closure without external power (other than that provided by the controller) being applied.

2.05 AUXILIARY CONTROL DEVICES

A. General

1. All materials and equipment used shall be standard components, of regular manufacture for this application.
2. All systems and components shall have been thoroughly tested and proven in actual use.
3. Exceptions to the indicated requirements will not be accepted.

B. Airflow Measurement Devices (AMD) with Temperature and Airflow Alarming Capability

1. Airflow measurement devices shall use the principle of thermal dispersion and provide one self-heated bead-in-glass thermistor and one zero power bead-in-glass thermistor at each sensing node.
 - a. Thermal dispersion devices that indirectly heat a thermistor are not acceptable.
 - b. The manufacturer's authorized representative shall review, approve placement and the operating airflow rates for each measurement location indicated on the plans.
 - c. Provide one AMD for each measurement location provided on the plans, schedules and/or control diagrams to determine the average airflow rate and temperature at each measurement location.
2. Each AMD shall be provided with a microprocessor-based transmitter and one or more sensor probes.
 - a. Devices that have electronic signal processing components on or in the sensor probe are not acceptable.
3. Airflow measurement shall be field configurable to determine the average actual or standard mass airflow rate.
 - a. Actual airflow rate calculations shall have the capability of being adjusted automatically by the transmitter for altitudes other than sea level.
4. Temperature measurement shall be field configurable to determine the velocity weighted temperate or simple arithmetic average temperature.
5. Sensor Probes
 - a. Sensor probes shall be constructed of gold anodized, 6063 aluminum alloy tube.

- b. Sensor probe mounting brackets shall be constructed of 304 stainless steel.
- c. Probe internal wiring between the connecting cable and sensor nodes shall be Kynar coated copper. PVC jacketed internal wiring is not acceptable.
- d. Probe internal wiring connections shall consist of solder joints and spot welds. Connectors of any type within the probe are not acceptable. Printed circuit boards within the probe are not acceptable.
- e. Probe internal wiring connections shall be sealed and protected from the elements and suitable for direct exposure to water.
- f. Each sensor probe shall be provided with an integral, FEP jacket, plenum rated CMP/CL2P, UL/cUL Listed cable rated for exposures from minus 67 deg F to 392 deg F and continuous and direct UV exposure. Plenum rated PVC jacket cables are not acceptable.
- g. Each sensor probe cable shall be provided with a connector plug with gold plated pins for connection to the transmitter.
- h. Each sensor probe shall contain one or more independently wired sensing nodes.
- i. Sensor node airflow and temperature calibration data shall be stored in a serial memory chip in the cable connecting plug and not require matching or adjustments to the transmitter.
- j. Each sensor node shall be provided with two bead-in-glass, hermetically sealed thermistors potted in a marine grade waterproof epoxy. Devices that use epoxy or glass encapsulated chip thermistors are not acceptable.
- k. Each thermistor shall be individually calibrated at a minimum of 3 temperatures to NIST-traceable temperature standards.
- l. Each sensor node shall be individually calibrated to NIST-traceable airflow standards at a minimum of 16 calibration points.
- m. The number of independent sensor nodes provided shall be as follows:

Area ft ²	# Sensor Nodes
≤ 0.5	1
> 0.5 & ≤ 1	2
> 1 & ≤ 2	4
> 2 & ≤ 4	6
> 4 & ≤ 8	8
> 8 & ≤ 12	12
> 12 & ≤ 14	14
> 14	16

- n. A total of 4 probes shall be required for openings with an aspect ratio ≤ 1.5 and with an area ≥ 25 ft².

6. Transmitter

- a. A remotely located microprocessor-based transmitter shall be provided for each measurement location.
- b. The transmitter shall be comprised of a main circuit board and interchangeable interface card.
- c. All printed circuit board interconnects, edge fingers, and test points shall be gold plated.
- d. All printed circuit boards shall be electroless nickel immersion gold (ENIG) plated.
- e. All receptacle plug pins shall be gold plated.
- f. The transmitter shall be capable of determining the average airflow rate and temperature of the sensor nodes.
- g. Separate integration buffers shall be provided for display airflow output, airflow signal output (analog and network) and individual sensor output (IR-interface).
- h. The transmitter shall be capable of providing a high and/or low airflow alarm.
- i. The transmitter shall be capable of identifying an AMD malfunction via the system status alarm and ignore any sensor node that is in a fault condition.
- j. The transmitter shall be provided with a 16-character, alpha-numeric, LCD display.
- k. The airflow rate, temperature, airflow alarm and system status alarm shall be visible on the display.
- l. The transmitter shall be provided with two field selectable (0-5/0-10 VDC or 4-20mA), scalable, isolated and over-current protected analog output signals and one isolated RS-485 (field selectable BACnet MS/TP or Modbus RTU) network connection;
- m. Analog output signals shall provide the total airflow rate and be field configurable to output one of the following: temperature, airflow alarm; or system status alarm.
- n. Network communications shall provide the average airflow rate, temperature, airflow alarm, system status alarm, individual sensor node airflow rates and individual sensor node temperatures.
- o. The transmitter shall be powered by 24 VAC and use a switching power supply that is over-current and over-voltage protected.
- p. The transmitter shall use a “watchdog” timer circuit to ensure continuous operation in the event of brown-out and/or power failure.

7. Performance

- a. Each sensing node shall have an airflow accuracy of $\pm 2\%$ of reading over an operating range of 0 to 5,000 FPM.
- b. Accuracy shall include the combined uncertainty of the sensor nodes and transmitter.
- c. Devices whose overall accuracy is based on individual accuracy specifications of the sensor probes and transmitter shall demonstrate compliance with this requirement over the entire operating range.
- d. Each sensing node shall have a temperature accuracy of plus minus 0.18 deg F over an operating range of minus 20 deg F to 160 deg F.

8. Listings and Certifications

- a. The AMD shall be UL873 Listed as an assembly.
- b. Devices claiming compliance with the UL Listing based on individual UL component listing are not acceptable.
- c. The AMD shall be BTL Listed.
- d. The AMD shall carry the CE Mark for European Union Shipments.

9. Installation

- a. Install in accordance with manufacturer's placement guidelines. A written report shall be submitted to the consulting mechanical engineer if any discrepancies are found.

10. Adjusting

- a. The AMD shall not be adjusted to match field measurements without approval from the consulting mechanical engineer when installations meet or exceed manufacturer's suggested placement.

11. Acceptable Manufacturers or equal:

- a. EBTRON GTX116-P
- b. Sierra
- c. Johnson Controls

C. Damper Actuators

- 1. Electronic damper actuators shall be of the direct-couple rotary type, suitable for mounting directly on the damper end shaft.
- 2. Electronic damper actuators shall be properly sized to provide sufficient torque to position the damper throughout its operating range.
- 3. On dampers with multiple sections, provide one actuator per section.

4. Damper actuators used on economizers and outside air dampers shall be of the spring return type.

D. Control Panels

1. All direct digital controllers mounted on HVAC equipment located indoors shall be installed in NEMA 4X enclosures.
2. All direct digital controllers mounted on HVAC equipment located outdoors shall be installed in NEMA 4X enclosures.
3. Enclosures shall be of suitable size to accommodate power supplies, relays, and accessories as required for the application.
4. Each enclosure shall include a subpanel for direct mounting of the enclosed devices, including matched key locks for all enclosures.
5. Construction
 - a. Control panels shall contain all relays, control switches, transformers, pilot lights, timers, time clocks, step controllers, gages, thermostats, and other accessories as necessary for the particular system.
 - b. The panels shall be constructed of aluminum with a baked enamel finish, and shall include a hinged front door with locking handle.
 - c. All manual switches and direct-reading gauges shall be flush-mounted on the front face, and identified by engraved and riveted Bakelite or laminated plastic nameplates with white letters on black background.
 - d. Manual switches shall be of heavy-duty, oil-tight construction.
6. Wiring
 - a. Control devices shall be pre-wired internally.
 - b. Terminate all wires leaving the panel at separate numbered terminal strips.
 - c. Provide individual connectors for every item of mechanical equipment, all integral and remote pilot lights, and other devices indicated for each panel.
 - d. Power and control circuit requirements shall be as indicated on the Electrical Drawings.
 - e. Identify all wires by color coding or numerical tags at both ends.
 - f. Wire each control device without splices to the terminal strip.
 - g. Provide integral circuit protection for all panel-mounted control devices.
 - h. Wire each panel with a single 20-amp, 120-volt, and AC feeder.
7. Panel electrical wiring diagrams shall be secured to the inside of the panel door.

E. Differential Pressure Switches (Air)

1. Provide differential pressure switches across fans and filters for status indication.
2. The differential pressure switches shall be provided with an adjustable setpoint from 0.05-in w.c. to 12-in w.c., with a switch differential that progressively increases from 0.04-in w.c. at minimum to 0.8-in w.c. at maximum.
3. The switch shall be SPDT-rated for 15A (non-inductive) at 125VAC.

F. Float Switches

1. Provide float switches in condensate drain pans as required by code.
2. Float switches shall utilize a magnetically actuated dry reed switch.
3. The float shall be constructed of seamless polypropylene.
4. The switch shall be SPDT-rated for 16A (non-inductive) at 120VAC.

G. Smoke Detectors

1. Division 26 – shall provide area smoke detectors and wire into the fire alarm system in accordance with the requirements of Section 23 05 00 – Common Work Results for HVAC.
2. Division 23 – shall provide HVAC duct detectors interlock wiring between duct smoke detectors and starter safety circuits.

H. Differential Pressure Transducers (Air)

1. Provide differential pressure transducers for monitoring air system and airflow measuring station differential pressures.
2. Differential pressure transducers shall be 100 percent solid-state, and shall include glass-on-silicon, ultra-stable capacitance sensors.
3. Each differential pressure transducer shall incorporate short circuit and reverse polarity protection.
4. Transducer output shall be either 0-10 VDC or 4-20 mA.
5. Provide the differential pressure transducers in an enclosure that is suitable for duct mounting.
6. The desired set point shall be within the top 50 percent of the transducer's operating range.

I. Current Sensing Relays

1. Provide current switches for indication of equipment status.
2. Amperage ratings shall be adjustable, with the desired set point being within the top 50 percent of the current relay's operating range.
3. Current sensing relays shall incorporate trip indication LEDs and shall be sized for proper operation with the equipment served.

J. Thermostats - Line Voltage

1. Materials: cold-rolled steel; beige thermoplastic; liquid sensing element
2. Contact Rating
 - a. 6 amps running; 36 amps locked rotor; 120 VAC
 - b. 3.5 amps running; 21 amps locked rotor; 208 VAC
 - c. 3.0 amps running; 8 amps locked rotor; 240 VAC
3. Switch Action: single-pole, double-throw; open on rising temperature
4. Sensing Element: coiled bulb and capillary
5. Range: 0 to 130 deg F
6. Manufacturer, or Equal
 - a. Dry Locations (no hose valves or open water processes in room): **Johnson Controls Model A19BAC-1** in NEMA 1 enclosure
 - b. Wet (hose valves or open water processes in room) or Outdoor Locations: **Johnson Controls Model A19PRC-1** in NEMA 4X enclosure.

K. Duct and Well Temperature Sensors

1. Sensors for duct and water temperature sensing shall incorporate either RTD or thermistor sensing devices.
2. The sensing element accuracy shall be 0.1 percent or better over the sensor span.
3. Where the element is being used for sensing mixed air or coil discharge temperatures or the duct cross sectional area is in excess of 10 sq ft, the element shall be of the averaging type.
4. Immersion sensors shall use matched Type 316 stainless steel bulb wells.
5. Provide duct and immersion sensors with conduit connection housings.
6. Provide sensors with adequate standoffs for insulation installation.

L. Occupancy Sensors

1. Occupancy sensors shall be provided with occupancy-sensing sensitivity adjustment, and an adjustable off-delay timer with a range encompassing 30 seconds to 15 minutes.
2. Occupancy sensors shall be rated for operation in ambient air temperatures from 50 deg F to 110 deg F.
3. Occupancy sensors shall be of the passive infrared type, and shall be provided with a multi-level, multi-segmented viewing lens and a conical field of view with a viewing angle of 180 degrees and a detection of at least 20 ft.

4. Passive infrared occupancy sensors shall provide field-adjustable background light-level adjustment with an adjustment range suitable to the light level in the sensed area.
5. Passive infrared sensors shall be immune to false triggering from radio frequency interference and other electromagnetic interference.

M. Selector Switches

1. Selector switches shall be of the 2- or 3-position, knob or key type as required by the sequence of operation.
2. Selector switches shall be of oil-tight construction and fitted with snap-fit contact blocks rated for 10A, 600 Vac/dc operation.
3. Provide labels indicating switch position.

N. Pushbutton Switches

1. Pushbutton switches shall be of either the maintained or momentary type as required by the sequence of operation.
2. Pushbutton switches shall be of oil-tight construction and fitted with snap-fit contact blocks rated for 10A, 600 Vac/dc operation.
3. Provide labels indicating switch function.

O. Pilot Lights

1. Provide pilot lights as required by the sequence of operation.
2. Pilot lights shall utilize multi-colored dome lenses and replaceable LED lamps.
3. Provide labels indicating light function.

2.06 WIRING AND RACEWAYS

- A. Provide copper wiring, plenum cable, and raceways as indicated in the applicable Sections of Division 26 – Electrical.
- B. All insulated wire shall be copper conductor, and UL-labeled for 194 deg F minimum service.

2.07 CONTROL SYSTEM CONTRACTORS AND MANUFACTURERS, OR EQUAL

- A. Schneider Electric – Authorized Field Office, Wadsworth Solutions
- B. Johnson Controls – Factory Branch Office
- C. Siemens – Factory Branch Office
- D. Honeywell – Factory Branch Office
- E. Trane – Authorized Field Office, Gardiner Trane

- F. The above list of manufacturers applies to controller software, custom application programming language, building controllers, custom application controllers; and application specific controllers; all other indicated products (e.g., sensors, valves, dampers and actuators) need not necessarily be manufactured by the above manufacturers.

PART 3 -- EXECUTION

3.01 EXAMINATION

- A. The Drawings shall be thoroughly examined for control device and equipment locations, and any discrepancies, conflicts, or omissions shall be reported to the Engineer for resolution before rough-in work is started.
- B. Inspect the Project Site to verify that the equipment may be installed as indicated, and report any discrepancies, conflicts, or omissions to the Engineer for resolution before rough-in work is started.
- C. Examine the Contract Documents for other parts of the Work, and if head room or space conditions appear inadequate, report these discrepancies to the Engineer and obtain written instructions for any changes that may be necessary to accommodate the Work with the work of others.
- D. Changes in the Work made necessary by the failure or neglect of the Contractor to report such discrepancies shall be considered to be part of the Contract.

3.02 COORDINATION

A. Site

- 1. Where the Work will be installed in close proximity to, or will interfere with, the work of other trades, the Contractor shall assist in accommodating space conditions to make a satisfactory adjustment.
- 2. If the Contractor installs the Work before coordinating with other trades, so as to cause any interference with the work of other trades, the Contractor shall make the necessary changes in the Work in order to correct the condition as part of the Contract.
- 3. Coordinate and schedule the Work with all other work in the same area, or with work that is dependent upon other work, in order to facilitate mutual progress.

B. Coordination with Other Controls

- 1. Other controls and control devices that are to be part of or integrated into the control system specified in this Section. These controls shall be integrated into the system and coordinated by the Contractor as follows:
- 2. All communication media and equipment shall be provided as specified in Part 2, "Communication" of this Specification.
- 3. Each supplier of a control product is responsible for the configuration, programming, startup, and testing of that product to meet the sequences of operation described in this Section.

4. The HVAC Subcontractor shall coordinate and resolve any incompatibility issues that arise between the control products provided under this Section and those provided under other Sections or divisions of this Specification.
5. The HVAC Subcontractor is responsible for the integration of control products provided by multiple suppliers regardless of where this integration is described within the contract documents.

C. Coordination with Facility SCADA System

1. Each Automatic Temperature Control System Panel (ATC) shall annunciate critical alarms with Pilot Light (Red) illumination.
2. All critical alarms will also be annunciated to the Facility SCADA system via hard wired contact closure of each respective alarm.
3. All other local Pilot Light indication (Green – System On) (Yellow – System Caution) (Blue – System Off) are considered non-critical and not required to be annunciated to the Facility SCADA System
4. Division 23 - shall provide necessary relays and termination strip for wiring to the Facility SCADA System. Conduit and wiring between the ATC Panel and the SCADA system shall be by Electrical Subcontractor
5. See general sheets for ATC panel and Pilot Light layout.

3.03 GENERAL WORKMANSHIP

- A. Install equipment, piping, wiring, and raceway parallel to building lines (i.e., horizontal, vertical, and parallel to walls) wherever possible.
- B. Provide sufficient slack and flexible connections to allow for vibration isolation of piping and equipment.
- C. Install all equipment in readily accessible locations as defined by the National Electrical Code (NEC).
- D. Verify the integrity of all wiring to ensure continuity and freedom from shorts and grounds.
- E. All equipment, installation, and wiring shall comply with acceptable industry specifications and standards for performance, reliability, and compatibility and shall be executed in strict adherence to local codes and standard practices.

3.04 WIRING FOR CONTROL SYSTEMS

- A. Furnish and install all wire, conduit, raceways, and cable systems as required for the complete operation of the Building Management and Control System in accordance with the requirements of Section 26 05 20 – Low-Voltage Electrical Power and Control Conductors and Cables.

3.05 SENSOR INSTALLATION

- A. Install sensors in accordance with the manufacturer's recommendations.

- B. Mount sensors rigidly and adequately for the environment within which the sensor operates.
- C. Room temperature sensors shall be installed on concealed junction boxes properly supported by the wall framing.
- D. All wires attached to sensors shall be air-sealed in their raceways or in the wall in order to stop air transmitted from other areas from affecting sensor readings.
- E. Averaging Sensors
 - 1. Sensors used in mixing plenums and hot and cold decks shall be of the averaging type.
 - 2. Averaging sensors shall be installed in a serpentine manner vertically across the duct.
 - 3. Support each bend with a capillary clip.
- F. Temperature Sensors
 - 1. All pipe-mounted temperature sensors shall be installed in wells.
 - 2. Install all liquid temperature sensors with heat-conducting fluid in thermal wells.
- G. Pressure Transducers
 - 1. The piping to the pressure ports on all pressure transducers shall contain a capped test port located adjacent to the transducer.
 - 2. All pressure transducers, other than those controlling VAV boxes, shall be located in field device panels and not on the equipment monitored or on ductwork.
 - 3. Mount transducers in a vibration-free location accessible for service without the need for ladders or special equipment.
 - 4. All air and water differential pressure sensors shall be provided with gauge tees mounted adjacent to the taps.

3.06 ACTUATORS

- A. Mount and link control damper actuators according to manufacturer's instructions.
- B. To compress seals when spring-return actuators are used on normally closed dampers, the actuator shall be powered to an approximately 5 degree open position, the damper closed manually, and then the linkage tightened.
- C. Check the operation of damper/actuator combination in order to confirm that the actuator modulates damper smoothly throughout the stroke to both OPEN and CLOSED positions.
- D. Provide all mounting hardware and linkages for the actuator installation.
- E. Electric and Electronic Actuators

1. Dampers

- a. Actuators shall be direct-mounted on the damper shaft or jackshaft unless indicated as a linkage installation.
- b. For low-leakage dampers with seals, the actuator shall be mounted with a minimum 5 degrees available for tightening the damper seals.
- c. Actuators shall be mounted in accordance with the manufacturer's recommendations.

3.07 CONTROLLERS

A. General

1. Provide a separate controller for each AHU or other HVAC system.
2. A DDC controller may control more than one system provided that all points associated with the system are assigned to the same DDC controller.
3. Control of an AHU or other mechanical equipment item shall not be split between multiple controllers; points used for control loop reset, such as outside air or space temperature, are exempt from this requirement.

B. Building Controllers and Custom Application Controllers

1. Building controllers and custom application controllers shall be selected to provide a minimum of 15 percent spare I/O point capacity for each point type found at each location.
2. If input points are not universal, 15 percent of each type shall be required, and if outputs are not universal, 15 percent of each type is required.
3. A minimum of one spare is required for each type of point used.
4. The future use of spare capacity shall require providing the field device, field wiring, point database definition, and custom software.
5. No additional controller boards or point modules shall be required to implement use of such spare points.

3.08 PROGRAMMING

A. Provide sufficient internal memory for the specified sequences of operation and trend logging.

B. Provide a minimum of 25 percent of available memory free for future use.

C. BACnet Points

1. Provide a detailed BACnet points list.
2. In addition to standard I/O information, the BACnet points list shall contain the proposed I/O names and BACnet object description.

3. The proposed I/O names and object descriptions are subject to change as directed by the Engineer.
4. Deliver an as-built list of the BACnet points with actual names and BACnet object addresses to the Owner at Project completion.

D. Software Programming

1. Provide programming for the system and adhere to the indicated sequences of operation.
2. Provide all other system programming necessary for the operation of the system but not indicated in this Section.
3. Embed into the control program sufficient comment statements to clearly describe each section of the program, reflecting the language used in the sequences of operation.

3.09 CONTROL SYSTEM CHECKOUT AND TESTING

A. Start-up Testing

1. All testing listed in this article shall be performed by the Contractor and shall make up part of the necessary verification of an operating control system.
2. This testing shall be completed before the Engineer is notified of the system demonstration.

B. Furnish all labor and test apparatus required to calibrate and prepare for service of all instruments, controls, and accessory equipment furnished under this Section.

C. Verify that all control wiring is properly connected, free of shorts and ground faults, and that terminations are tight.

D. Enable the control systems and verify calibration of all input devices individually.

E. Perform calibration procedures according to manufacturers' recommendations.

F. Verify that all binary output devices (e.g., relays, solenoid valves, two-position actuators and control valves, magnetic starters, etc.) operate properly and that the normal positions are correct.

G. Verify that all analog output devices (e.g., I/Ps, actuators, etc.) are functional, that start and span are correct, and that direction and normal positions are correct.

H. Verify that the system operation adheres to the sequences of operation.

I. Simulate and observe all modes of operation by overriding and varying inputs and schedules.

J. Tune all PID loops and optimize START/STOP routines.

K. Alarms and Interlocks

1. Check each alarm separately by including an appropriate signal at a value that will trip the alarm.
2. Interlocks shall be tripped using field contacts to check the logic, as well as to ensure that the fail-safe condition for all actuators is in the proper direction.
3. Interlock actions shall be tested by simulating alarm conditions to check the initiating value of the variable and interlock action.

3.10 CONTROL SYSTEM DEMONSTRATION AND ACCEPTANCE

A. Demonstration

1. Prior to acceptance, the control system shall undergo a series of performance tests to verify operation and compliance with this Section.
2. These tests shall occur after the Contractor has completed the installation, started up the system, and performed tests.

3.11 TRAINING

A. Provide a minimum of 2 on-site or classroom training sessions of 1 day each, throughout the Contract period for personnel designated by the Owner.

B. Additional Training

1. Provide 1 additional training session at 6 and 12 months following the facility's turnover.
2. Each session to be 1 day in length and shall be coordinated with the Owner.

C. Train the designated Owner's staff to perform the following items:

1. Day-to-day Operations:
 - a. Operate the system proficiently
 - b. Understand the control system architecture and configuration
 - c. Understand the DDC system components
 - d. Understand system operation, including DDC system control and optimizing routines (algorithms)
 - e. Operate the workstation and peripherals
 - f. Log on and off the system
 - g. Access graphics, point reports, and logs
 - h. Adjust and change system set points, time schedules, and holiday schedules
 - i. Recognize malfunctions of the system by observation of the system graphics, trend logs, and other system tools
 - j. Understand system drawings and the operation and maintenance manual

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k. Understand the job layout and location of control components

l. Access data from the DDC controllers and ASCs

m. Operate portable operator terminals

2. Advanced Operations:

a. Create, delete, and modify alarms, including annunciation and routing of these items

b. Create, delete, and modify trend and graph or print these both on ad-hoc basis and at user-definable time intervals

c. Create, delete, and modify reports

d. Add, remove, and modify the system's physical points

e. Create, modify, and delete programming

f. Add panels when required

g. Add operator interface stations

h. Create, delete, and modify system displays, both graphical and others

i. Perform DDC system field checkout procedures

j. Perform DDC controller unit operation and maintenance procedures

k. Configure hardware including controllers and I/O points

l. Maintain, calibrate, and replace system components

3. System Management and Administration:

a. Maintain software and prepare backups

b. Interface with job-specific, third-party operator software

c. Add new users and understand password security procedures

D. Groupings

1. Split the above objectives into 3 logical groupings, as follows and based on the above descriptions.

2. Participants may attend one or more of these, depending on their level of knowledge required.

a. Day-to-day operators

b. Advanced operators

c. System managers and administrators

- E. Provide a course outline and materials in accordance with the "Submittals" article in Part 1 of this Section.
- F. The instructor shall provide one copy of training material per student
- G. The instructor shall be factory-trained and experienced in presenting this material.
- H. Classroom training shall be performed using a network of working controllers representative of the installed hardware.

END OF SECTION

SECTION 23 23 00– REFRIGERATION PIPING

PART 1 -- GENERAL

1.01 SUMMARY

- A. The Contractor shall provide copper tube for refrigeration service, complete and in place, as indicated in accordance with the Contract Documents

1.02 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

A. Reference Specifications

01 33 17	Structural Design, Support, and Anchorage
07 92 13	Elastomeric Joint Sealants

B. Reference Standards

AIR-CONDITIONING, HEATING AND REFRIGERATION INSTITUTE (AHRI)	
AHRI 710 (2009)	Performance Rating of Liquid-Line Driers
AHRI 711 (2009)	Performance Rating of Liquid-Line Driers
AHRI 720 (2002)	Refrigerant Access Valves and Hose Connectors
ANSI/AHRI 750 (2007)	Thermostatic Refrigerant Expansion Valves
ANSI/AHRI 760 (2007)	Performance Rating of Solenoid Valves for Use With Volatile Refrigerants
AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR-CONDITIONING ENGINEERS (ASHRAE)	
ANSI/ASHRAE 15 & 34	
ASHRAE 17 (2008)	Method of Testing Capacity of Thermostatic Refrigerant Expansion Valves
AMERICAN WELDING SOCIETY AWS A5.8/A5.8M (2011)	Specification for Filler Metals for Brazing and Braze Welding, AWS BRH (2007; 5th Ed) Brazing Handbook, AWS D1.1/D1.1M (2010) Structural Welding Code – Steel, AWS Z49.1 (2005) Safety in Welding and Cutting and Allied Processes
ASME INTERNATIONAL (ASME)	
ASME B1.20.1 (1983; R 2006)	Pipe Threads, General Purpose
ASME B16.11 (2009)	Forged Fittings, Socket-Welding and Threaded
ASME B16.21 (2011)	Nonmetallic Flat Gaskets for Pipe Flanges
ASME B16.22 (2001; R 2010)	Standard for Wrought Copper and Copper Alloy Solder Joint Pressure Fittings
ASME B16.26 (2011)	Standard for Cast Copper Alloy Fittings for Flared Copper Tubes
ASME B16.3 (2011)	Malleable Iron Threaded Fittings, Classes 150 and 300
ASME B16.5 (2009)	Pipe Flanges and Flanged Fittings: NPS 1/2 Through NPS 24 Imperial Standard
ASME B16.9 (2007)	Standard for Factory-Made Wrought Steel Buttwelding Fittings

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ASME B31.1 (2010)	Power Piping
ASME B31.5 (2010)	Refrigeration Piping and Heat Transfer Components
ASME B31.9 (2011)	Building Services Piping
ASME B40.100 (2005; R 2010)	Pressure Gauges and Gauge Attachments
ASME BPVC SEC IX (2010)	BPVC Section IX-Welding and Brazing Qualifications
ASTM INTERNATIONAL (ASTM)	
ASTM A193/A193M (2011)	Standard Specification for Alloy-Steel and Stainless Steel Bolting Materials for High-Temperature Service and Other Special Purpose Applications
ASTM A334/A334M (2004a; R 2010)	Standard Specification for Seamless and Welded Carbon and Alloy-Steel Tubes for Low-Temperature Service
ASTM A53/A53M (2010)	Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
ASTM A653/A653M (2011)	Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process
ASTM B117 (2011)	Standard Practice for Operating Salt Spray (Fog) Apparatus
ASTM B280 (2008)	Standard Specification for Seamless Copper Tube for Air Conditioning and Refrigeration Field Service
ASTM B32 (2008)	Standard Specification for Solder Metal
ASTM B62 (2009)	Standard Specification for Composition Bronze or Ounce Metal Castings
ASTM B75 (2002; R 2010)	Standard Specification for Seamless Copper Tube
ASTM B813 (2010)	Standard Specification for Liquid and Paste Fluxes for Soldering of Copper and Copper Alloy Tube
ASTM D3308 (2006)	PTFE Resin Skived Tape
ASTM D520 (2000; R 2011)	Zinc Dust Pigment
ASTM E84 (2011b)	Standard Test Method for Surface Burning Characteristics of Building Materials

1.03 QUALITY ASSURANCE

- A. Submit 4 copies of qualified procedures, and list of names and identification symbols of qualified welders and welding operators, prior to non-factory welding operations. Piping shall be welded in accordance with the qualified procedures using performance qualified welders and welding operators. Procedures and welders shall be qualified in accordance with ASME BPVC SEC IX. Welding procedures qualified by others, and welders and welding operators qualified by another employer may be accepted as permitted by ASME B31.1. Notify the Contracting Officer 24 hours in advance of tests to be performed at the work site, if practical. The welder or welding operator shall apply the personally assigned symbol near each weld made, as a permanent record.
- B. Contract Drawings: Because of the small scale of the drawings, it is not possible to indicate all offsets, fittings, and accessories that may be required. Carefully investigate the plumbing, fire protection, electrical, structural and finish conditions that would affect the work to be performed and arrange such work accordingly, furnishing required offsets, fittings, and accessories to meet such conditions.

1.04 DELIVERY, STORAGE, AND HANDLING

- A. Protect stored items from the weather, humidity and temperature variations, dirt and dust, or other contaminants. Proper protection and care of all material both before and during installation is the Contractor's responsibility. Replace any materials found to be damaged at the Contractor's expense. During installation, cap piping and similar openings to keep out dirt and other foreign matter.

PART 2 -- PRODUCTS

2.01 REFRIGERANT PIPING SYSTEM

- A. Refrigerant piping, valves, fittings, and accessories shall be in accordance with ANSI/ASHRAE 15 & 34 and ASME B31.5, except as specified herein. Refrigerant piping, valves, fittings, and accessories shall be compatible with the fluids used and capable of withstanding the pressures and temperatures of the service. Refrigerant piping, valves, and accessories used for refrigerant service shall be cleaned, dehydrated, and sealed (capped or plugged) prior to shipment from the manufacturer's plant. Submit drawings, at least 2 weeks prior to beginning construction, provided in adequate detail to demonstrate compliance with contract requirements. Drawings shall consist of:

1. Piping layouts which identify all valves and fittings.
2. Plans and elevations which identify clearances required for maintenance and operation.

2.02 PIPE, FITTINGS AND END CONNECTIONS (JOINTS)

A. Copper Tubing

1. Copper tubing shall conform to ASTM B280 annealed or hard drawn as required.
2. Copper tubing shall be soft annealed where bending is required and hard drawn where no bending is required.
3. Soft annealed copper tubing shall not be used in sizes larger than 1 3/8-in . Joints shall be brazed except that joints on lines 7/8-in and smaller may be flared. Cast copper alloy fittings for flared copper tube shall conform to ASME B16.26 and ASTM B62.
4. Wrought copper and bronze solder-joint pressure fittings shall conform to ASME B16.22 and ASTM B75M ASTM B75. Joints and fittings for brazed joint shall be wrought-copper or forged-brass sweat fittings.
5. Cast sweat-type joints and fittings shall not be allowed for brazed joints. Brass or bronze adapters for brazed tubing may be used for connecting tubing to flanges and to threaded ends of valves and equipment.

B. Solder

1. Solder shall conform to ASTM B32, grade Sb5, tin-antimony alloy for service pressures up to 150 psig. Solder flux shall be liquid or paste form, non-corrosive and conform to ASTM B813.

C. Brazing Filler Metal

1. Filler metal shall conform to AWS A5.8/A5.8M, Type BAg-5 with AWS Type 3 flux, except Type BCuP-5 or BCuP-6 may be used for brazing copper-to-copper joints.

2.03 VALVES

A. Valves, General

1. Valves shall be designed, manufactured, and tested specifically for refrigerant service. Valve bodies shall be of brass, bronze, steel, or ductile iron construction. Valves 1-in and smaller shall have brazed or socket welded connections. Valves larger than 1-in shall have butt welded end connections.
2. Threaded end connections shall not be used, except in pilot pressure or gauge lines where maintenance disassembly is required and welded flanges cannot be used. Internal parts shall be removable for inspection or replacement without applying heat or breaking pipe connections.
3. Valve stems exposed to the atmosphere shall be stainless steel or corrosion resistant metal plated carbon steel. Direction of flow shall be legibly and permanently indicated on the valve body.
4. Control valve inlets shall be fitted with integral or adapted strainer or filter where recommended or required by the manufacturer. Purge, charge and receiver valves shall be of manufacturer's standard configuration.

B. Refrigerant Stop Valves

1. Valve shall be the globe or full-port ball type with a back-seating stem especially packed for refrigerant service. Valve packing shall be replaceable under line pressure. Valve shall be provided with a handwheel operator and a seal cap. Valve shall be the straight or angle pattern design as indicated.

C. Check Valves

1. Valve shall be the swing or lift type as required to provide positive shutoff at the differential pressure indicated. Valve shall be provided with resilient seal.

D. Liquid Solenoid Valves

1. Valves shall comply with ANSI/AHRI 760 and be suitable for continuous duty with applied voltages 15 percent under and 5 percent over nominal rated voltage at maximum and minimum encountered pressure and temperature service conditions.
2. Valves shall be direct-acting or pilot-operating type, packless, except that packed stem, seal capped, manual lifting provisions shall be furnished. Solenoid coils shall be moisture-proof, UL approved, totally encapsulated or encapsulated and metal jacketed as required.
3. Valves shall have safe working pressure of 400 psi and a maximum operating pressure differential of at least 200 psi at 85 percent rated voltage. Valves shall have an operating pressure differential suitable for the refrigerant used.

E. Expansion Valves

1. Valve shall conform to ANSI/AHRI 750 and ASHRAE 17. Valve shall be the diaphragm and spring-loaded type with internal or external equalizers, and bulb and capillary tubing.
2. Valve shall be provided with an external superheat adjustment along with a seal cap. Internal equalizers may be utilized where flowing refrigerant pressure drop between outlet of the valve and inlet to the evaporator coil is negligible and pressure drop across the evaporator is less than the pressure difference corresponding to 2 deg F of saturated suction temperature at evaporator conditions. Bulb charge shall be determined by the manufacturer for the application and such that liquid will remain in the bulb at all operating conditions. Gas limited liquid charged valves and other valve devices for limiting evaporator pressure shall not be used without a distributor or discharge tube or effective means to prevent loss of control when bulb becomes warmer than valve body.
3. Pilot-operated valves shall have a characterized plug to provide required modulating control. A de-energized solenoid valve may be used in the pilot line to close the main valve in lieu of a solenoid valve in the main liquid line. An isolatable pressure gauge shall be provided in the pilot line, at the main valve.
4. Automatic pressure reducing or constant pressure regulating expansion valves may be used only where indicated or for constant evaporator loads.

F. Safety Relief Valves

1. Valve shall be the two-way type, unless indicated otherwise.
2. Valve shall bear the ASME code symbol. Valve capacity shall be certified by the National Board of Boiler and Pressure Vessel Inspectors. Valve shall be of an automatically reseating design after activation.

G. Evaporator Pressure Regulators, Direct-Acting

1. Valve shall include a diaphragm/spring assembly, external pressure adjustment with seal cap, and pressure gauge port. Valve shall maintain a constant inlet pressure by balancing inlet pressure on diaphragm against an adjustable spring load. Pressure drop at system design load shall not exceed the pressure difference corresponding to a 2 deg F change in saturated refrigerant temperature at evaporator operating suction temperature. Spring shall be selected for indicated maximum allowable suction pressure range.

H. Refrigerant Access Valves

1. Refrigerant access valves and hose connections shall be in accordance with AHRI 720.

2.04 PIPING ACCESSORIES

A. Filter Driers

1. Driers shall conform to AHRI 711AHRI 710. Sizes 5/8-in and larger shall be the full flow, replaceable core type. Sizes 1/2-in and smaller shall be the sealed type. Cores shall be of suitable desiccant that will not plug, cake, dust, channel, or break down, and shall remove water, acid, and foreign material from the refrigerant.
2. Filter driers shall be constructed so that none of the desiccant will pass into the refrigerant lines. Minimum bursting pressure shall be 1,500 psi .

B. Sight Glass and Liquid Level Indicator

1. Assembly and Components: Assembly shall be pressure- and temperature-rated and constructed of materials suitable for the service. Glass shall be borosilicate type.
2. Ferrous components subject to condensation shall be electro-galvanized.

C. Gauge Glass

1. Gauge glass shall include top and bottom isolation valves fitted with automatic checks, and packing followers; red-line or green-line gauge glass; elastomer or polymer packing to suit the service; and gauge glass guard.

D. Bull's-Eye and Inline Sight Glass Reflex Lens

1. Bull's-eye and inline sight glass reflex lens shall be provided for dead-end liquid service. For pipe line mounting, two plain lenses in one body suitable for backlighting viewing shall be provided.

E. Moisture Indicator

1. Indicator shall be a self-reversible action, moisture reactive, color changing media. Indicator shall be furnished with full-color-printing tag containing color, moisture and temperature criteria. Unless otherwise indicated, the moisture indicator shall be an integral part of each corresponding sight glass.

F. Vibration Dampeners

1. Dampeners shall be of the all-metallic bellows and woven-wire type.

G. Flexible Pipe Connectors

1. Connector shall be a composite of interior corrugated phosphor bronze or Type 300 Series stainless steel, as required for fluid service, with exterior reinforcement of bronze, stainless steel or monel wire braid. Assembly shall be constructed with a safety factor of not less than 4 at 300 deg F . Unless otherwise indicated, the length of a flexible connector shall be as recommended by the manufacturer for the service intended.

H. Strainers

1. Strainers used in refrigerant service shall have brass or cast iron body, Y-or angle-pattern, cleanable, not less than 60-mesh noncorroding screen of an area to provide net free area not less than ten times the pipe diameter with pressure rating compatible with the refrigerant service. Screens shall be stainless steel or monel and reinforced spring-loaded where necessary for bypass-proof construction.

I. Pressure and Vacuum Gauges

1. Gauges shall conform to ASME B40.100 and shall be provided with throttling type needle valve or a pulsation dampener and shut-off valve. Gauge shall be a minimum of 3 ½-in in diameter with a range from 0 psig to approximately 1.5 times the maximum system working pressure. Each gauge range shall be selected so that at normal operating pressure, the needle is within the middle-third of the range

J. Temperature Gauges

1. Temperature gauges shall be the industrial duty type and be provided for the required temperature range. Gauges shall have Fahrenheit scale in 2 degrees graduations scale (black numbers) on a white face. The pointer shall be adjustable. Rigid stem type temperature gauges shall be provided in thermal wells located within 5 ft of the finished floor. Universal adjustable angle type or remote element type temperature gauges shall be provided in thermal wells located 5 ft to 7 ft above the finished floor. Remote element type temperature gauges shall be provided in thermal wells located 7 ft above the finished floor.

K. Stem Cased-Glass

1. Stem cased-glass case shall be polished stainless steel or cast aluminum, 9-in long, with clear acrylic lens, and non-mercury filled glass tube with indicating-fluid column.

L. Bimetallic Dial

1. Bimetallic dial type case shall be not less than 3 ½-in , stainless steel, and shall be hermetically sealed with clear acrylic lens.
2. Bimetallic element shall be silicone dampened and unit fitted with external calibrator adjustment. Accuracy shall be one percent of dial range.

M. Liquid-, Solid-, and Vapor-Filled Dial

1. Liquid-, solid-, and vapor-filled dial type cases shall be not less than 3 ½-in , stainless steel or cast aluminum with clear acrylic lens.
2. Fill shall be nonmercury, suitable for encountered cross-ambients, and connecting capillary tubing shall be double-braided bronze.

N. Thermal Well

1. Thermal well shall be identical size, 1/2-in or 3/4-in NPT connection, brass or stainless steel. Where test wells are indicated, provide captive plug-fitted type 1/2-in NPT connection suitable for use with either engraved stem or standard separable socket thermometer or thermostat. Mercury shall not be used in thermometers. Extended neck thermal wells shall be of sufficient length to clear insulation thickness by 1-in .

O. Pipe Hangers, Inserts, and Supports

1. Pipe hangers, inserts, guides, and supports shall conform to MSS SP-58 and MSS SP-69.

P. Escutcheons

1. Escutcheons shall be chromium-plated iron or chromium-plated brass, either one piece or split pattern, held in place by internal spring tension or set screws.

2.05 FABRICATION

A. Factory Coating

1. Unless otherwise specified, equipment and component items, when fabricated from ferrous metal, shall be factory finished with the manufacturer's standard finish, except that items located outside of buildings shall have weather resistant finishes that will withstand [125] [500] hours exposure to the salt spray test specified in ASTM B117 using a 5 percent sodium chloride solution. Immediately after completion of the test, the specimen shall show no signs of blistering, wrinkling, cracking, or loss of adhesion and no sign of rust creepage beyond 1/8-in on either side of the scratch mark. Cut edges of galvanized surfaces where hot-dip galvanized sheet steel is used shall be coated with a zinc-rich coating conforming to ASTM D520, Type I.

B. Refrigerant Pipe Insulation

1. Insulation shall be a flexible, closed-cell elastomeric pipe insulation, AP Armaflex, AC Accoflex.
2. Adhesive shall be Armaflex 520, 520 Black or 520 BLV Adhesive. The insulation must conform to ASTM C534 Grade 1, Type I.
3. Insulation materials shall have a closed cell structure to prevent moisture from wicking which makes it an efficient insulation.
4. Insulation materials shall be manufactured without the use of CFC's, HFC's or HCFC's. It is also formaldehyde free, low VOCs, fiber free, dust free and resists mold and mildew.
5. Insulation materials shall have a flame-spread index of less than 25 and a smoke-developed index of less than 50 as tested in accordance with ASTM E 84. In addition, the products, when tested, shall not melt or drip flaming particles, and the flame shall not be progressive.

6. Insulation materials shall have a maximum thermal conductivity of 0.27 Btu-in./h-ft²-deg F at a 75 deg F mean temperature as tested in accordance with ASTM C 177 or ASTM C 518.
7. Insulation materials shall have a maximum water vapor transmission of 0.08 per m-in when tested in accordance with ASTM E 96, Procedure A.
8. As a minimum, insulated items installed indoors shall have a flame spread index no higher than 75 and a smoke developed index no higher than 150.
9. Insulated items (no jacket) installed indoors and which are located in air plenums, in ceiling spaces, and in attic spaces shall have a flame spread index no higher than 25 and a smoke developed index no higher than 50.
10. Flame spread and smoke developed indexes shall be determined by ASTM E84.
11. Insulation shall be tested in the same density and installed thickness as the material to be used in the actual construction. Material supplied by a manufacturer with a jacket shall be tested as a composite material.
12. Jackets, facings, and adhesives shall have a flame spread index no higher than 25 and a smoke developed index no higher than 50 when tested in accordance with ASTM E84.
13. All liquid and suction lines shall be insulated continuously from a point 6-in inside the display case to the suction service valve at the compressor.
14. All low temperature lines (plus 10 deg F and below) shall be insulated with a minimum of 1-in wall thickness.
15. All medium and high temperature lines (above plus 10 deg F) shall be insulated with a minimum of ¾-in wall thickness.
16. Heat reclaim lines shall be insulated from the condensing unit to the heat reclaim units with ¾-in thickness.
17. All refrigerant copper lines must be free of extraneous chemicals such as corrosive cleaners or building materials' dust prior to the installation of the insulation. The insulation must be clean and dry prior to installation.
18. Refrigerant pipe shall be sealed while slipping on insulation to prevent foreign matter from entering the tube.
19. Insulation is to be slid onto pipe; longitudinal slitting of the insulation is not allowed except on mitered sections. Insulation shall be pushed onto pipe, not pulled.
20. Insulation shall be mitered, pre-adhered and longitudinally slit inside throat to fit over all P-traps, tees and elbows or bends over 90 degrees.
21. All butt joints and mitered seams shall be adhered with full coverage of adhesive on both surfaces. Insulation shall not be stretched when adhering.
22. Insulation must be installed in an adequately ventilated area. It may be necessary to increase insulation thickness if adequate ventilation is not present, Do not crowd the insulation, allow for adequate air movement.

23. At the beginning, at every 12 ft to 18 ft , and at the ends of piping runs, the insulation shall be adhered directly to the copper using a 2-in strip of adhesive. Insulation should not be adhered to the pipe at the extreme low points in any piping run.
24. Saddles shall be installed under all insulated lines at unistrut clamps, clevis hangers, or locations where insulation may be compressed.
25. Armaflex IPH or NPH insulation pipe hangers can be installed at the compression locations and the seams shall be sealed with Armaflex 520, 520 Black or 520 BLV contact adhesive.
26. To minimize the movement of Armaflex, a pair of non-skid pads be adhered to the clamps. In addition, to prevent loosening of the clamps, use of an anti-vibratory fastener, such as a nylon-locking nut.
27. Wood dowels or blocks, of a thickness equal to the insulation, shall be inserted and must be completely sealed into the insulation at the saddle locations. All seams shall be sealed with Armaflex 520, 520 Black or 520 BLV contact adhesive.
28. Hangers clamped directly to the pipe shall be insulated over the hanger; insulation shall be fully adhered to the hanger. In addition, hangers with double rods shall be insulated between the rods. All seams of the insulation shall be sealed with adhesive.
29. All insulation exposed to sunlight or installed outdoors shall be protected with two coats of WB Armaflex Finish or weather resistant coating.

PART 3 -- EXECUTION

3.01 EXAMINATION

- A. After becoming familiar with all details of the work, perform a verification of dimensions in the field. Submit a letter, at least 2 weeks prior to beginning construction, including the date the site was visited, conformation of existing conditions, and any discrepancies found before performing any work.

3.02 INSTALLATION

- A. Pipe and fitting installation shall conform to the requirements of ASME B31.1. Pipe shall be cut accurately to measurements established at the jobsite, and worked into place without springing or forcing, completely clearing all windows, doors, and other openings. Cutting or other weakening of the building structure to facilitate piping installation will not be permitted without written approval. Pipe or tubing shall be cut square, shall have burrs removed by reaming, and shall permit free expansion and contraction without causing damage to the building structure, pipe, joints, or hangers.
 1. Directional Changes: Changes in direction shall be made with fittings, except that bending of pipe 4-in and smaller will be permitted, provided a pipe bender is used and wide weep bends are formed. Mitering or notching pipe or other similar construction to form elbows or tees will not be permitted. The centerline radius of bends shall not be less than 6 diameters of the pipe. Bent pipe showing kinks, wrinkles, flattening, or other malformations will not be accepted.

2. Functional Requirements: Piping shall be installed 1/2-in/10 ft of pipe in the direction of flow to ensure adequate oil drainage. Open ends of refrigerant lines or equipment shall be properly capped or plugged during installation to keep moisture, dirt, or other foreign material out of the system. Piping shall remain capped until installation. Equipment piping shall be in accordance with the equipment manufacturer's recommendations and the contract drawings. Equipment and piping arrangements shall fit into space allotted and allow adequate acceptable clearances for installation, replacement, entry, servicing, and maintenance.

B. Fittings and End Connections

1. Threaded Connections: Threaded connections shall be made with tapered threads and made tight with PTFE tape complying with ASTM D3308 or equivalent thread-joint compound applied to the male threads only. Not more than three threads shall show after the joint is made.

C. Brazed Connections

1. Brazing shall be performed in accordance with AWS BRH, except as modified herein. During brazing, the pipe and fittings shall be filled with a pressure regulated inert gas, such as nitrogen, to prevent the formation of scale. Before brazing copper joints, both the outside of the tube and the inside of the fitting shall be cleaned with a wire fitting brush until the entire joint surface is bright and clean. Brazing flux shall not be used. Surplus brazing material shall be removed at all joints. Steel tubing joints shall be made in accordance with the manufacturer's recommendations. Joints in steel tubing shall be painted with the same material as the baked-on coating within 8 hours after joints are made. Tubing shall be protected against oxidation during brazing by continuous purging of the inside of the piping using nitrogen. Piping shall be supported prior to brazing and not be sprung or forced.

D. Welded Connections

1. Welded joints in steel refrigerant piping shall be fusion-welded. Branch connections shall be made with welding tees or forged welding branch outlets. Pipe shall be thoroughly cleaned of all scale and foreign matter before the piping is assembled. During welding the pipe and fittings shall be filled with an inert gas, such as nitrogen, to prevent the formation of scale. Beveling, alignment, heat treatment, and inspection of weld shall conform to ASME B31.1. Weld defects shall be removed and rewelded at no additional cost to the Government. Electrodes shall be stored and dried in accordance with AWS D1.1/D1.1M or as recommended by the manufacturer. Electrodes that have been wetted or that have lost any of their coating shall not be used.

E. Flared Connections

1. When flared connections are used, a suitable lubricant shall be used between the back of the flare and the nut in order to avoid tearing the flare while tightening the nut.

F. Flanged Connections

1. When steel refrigerant piping is used, union or flange joints shall be provided in each line immediately preceding the connection to each piece of equipment requiring maintenance, such as compressors, coils, chillers, control valves, and other similar items. Flanged joints shall be assembled square end tight with matched flanges, gaskets, and bolts. Gaskets shall be suitable for use with the refrigerants to be handled.

G. Valves General

1. Refrigerant stop valves shall be installed on each side of each piece of equipment such as compressors condensers, evaporators, receivers, and other similar items in multiple-unit installation, to provide partial system isolation as required for maintenance or repair. Stop valves shall be installed with stems horizontal unless otherwise indicated. Ball valves shall be installed with stems positioned to facilitate operation and maintenance. Isolating valves for pressure gauges and switches shall be external to thermal insulation. Safety switches shall not be fitted with isolation valves. Filter dryers having access ports may be considered a point of isolation. Purge valves shall be provided at all points of systems where accumulated non-condensable gases would prevent proper system operation. Valves shall be furnished to match line size, unless otherwise indicated or approved.

H. Expansion Valves

1. Expansion valves shall be installed with the thermostatic expansion valve bulb located on top of the suction line when the suction line is less than 2 1/8-in in diameter and at the 4 o'clock or 8 o'clock position on lines larger than 2 1/8-in . The bulb shall be securely fastened with two clamps. The bulb shall be insulated. The bulb shall be installed in a horizontal portion of the suction line, if possible, with the pigtail on the bottom. If the bulb must be installed in a vertical line, the bulb tubing shall be facing up.

I. Valve Identification

1. Each system valve, including those which are part of a factory assembly, shall be tagged. Tags shall be in alphanumeric sequence, progressing in direction of fluid flow. Tags shall be embossed, engraved, or stamped plastic or nonferrous metal of various shapes, sized approximately 1 3/8-in diameter, or equivalent dimension, substantially attached to a component or immediately adjacent thereto. Tags shall be attached with nonferrous, heavy duty, bead or link chain, 14-gauge annealed wire, nylon cable bands or as approved. Tag numbers shall be referenced in Operation and Maintenance Manuals and system diagrams.

J. Vibration Dampers

1. Vibration damper shall be provided in the suction and discharge lines on spring mounted compressors. Vibration dampers shall be installed parallel with the shaft of the compressor and shall be anchored firmly at the upstream end on the suction line and the downstream end in the discharge line.

K. Strainers

1. Strainers shall be provided immediately ahead of solenoid valves and expansion devices. Strainers may be an integral part of an expansion valve.

L. Filter Dryer

1. A liquid line filter dryer shall be provided on each refrigerant circuit located such that all liquid refrigerant passes through a filter dryer.
2. Dryers shall be sized in accordance with the manufacturer's recommendations for the system in which it is installed.
3. Dryers shall be installed such that it can be isolated from the system, the isolated portion of the system evacuated, and the filter dryer replaced. Dryers shall be installed in the horizontal position except replaceable core filter dryers may be installed in the vertical position with the access flange on the bottom.

M. Sight Glass

1. A moisture indicating sight glass shall be installed in all refrigerant circuits downstream of all filter dryers and where indicated. Sight glasses shall be full line size.

N. Discharge Line Oil Separator

1. Discharge line oil separator shall be provided in the discharge line from each compressor. Oil return line shall be connected to the compressor as recommended by the compressor manufacturer.

O. Accumulator

1. Accumulators shall be provided in the suction line to each compressor.

P. Flexible Pipe Connectors

1. Connectors shall be installed perpendicular to line of motion being isolated. Piping for equipment with bidirectional motion shall be fitted with two flexible connectors, in perpendicular planes. Reinforced elastomer flexible connectors shall be installed in accordance with manufacturer's instructions. Piping guides and restraints related to flexible connectors shall be provided as required.

Q. Temperature Gauges

1. Temperature gauges shall be located specifically on, but not limited to the following: the liquid line leaving a receiver and the suction line at each evaporator or liquid cooler. Thermal wells for insertion thermometers and thermostats shall extend beyond thermal insulation surface not less than 1-in.

R. Pipe Hangers, Inserts, and Supports

1. Pipe hangers, inserts, and supports shall conform to MSS SP-58 and MSS SP-69, except as modified herein. Pipe hanger types 5, 12, and 26 shall not be used. Hangers used to support piping 2-in and larger shall be fabricated to permit adequate adjustment after erection while still supporting the load. Piping subjected to vertical movement, when operating temperatures exceed ambient temperatures, shall be supported by variable spring hangers and supports or by constant support hangers.

S. Hangers

1. Type 3 shall not be used on insulated piping. Type 24 may be used only on trapeze hanger systems or on fabricated frames.

T. Inserts

1. Type 18 inserts shall be secured to concrete forms before concrete is placed. Continuous inserts which allow more adjustments may be used if they otherwise meet the requirements for Type 18 inserts.

U. C-Clamps

1. Type 19 and 23 C-clamps shall be torqued in accordance with MSS SP-69 and have both locknuts and retaining devices, furnished by the manufacturer.
2. Field-fabricated C-clamp bodies or retaining devices are not acceptable.

V. Angle Attachments

1. Type 20 attachments used on angles and channels shall be furnished with an added malleable-iron heel plate or adapter.

W. Saddles and Shields

1. Where Type 39 saddle or Type 40 shield are permitted for a particular pipe attachment application, the Type 39 saddle, connected to the pipe, shall be used on all pipe 4-in and larger when the temperature of the medium is 60 deg F or higher. Type 40 shields shall be used on all piping less than 4-in and all piping 4-in and larger carrying medium less than 60 deg F. A high density insulation insert of cellular glass shall be used under the Type 40 shield for piping 2-in and larger.

X. Horizontal Pipe Supports

1. Horizontal pipe supports shall be spaced as specified in MSS SP-69 and a support shall be installed not over 1 ft from the pipe fitting joint at each change in direction of the piping. Pipe supports shall be spaced not over 5 ft apart at valves. Pipe hanger loads suspended from steel joist with hanger loads between panel points in excess of 50 pounds shall have the excess hanger loads suspended from panel points.

Y. Vertical Pipe Supports

1. Vertical pipe shall be supported at each floor, except at slab-on-grade, and at intervals of not more than 15 ft not more than 28 ft from end of risers, and at vent terminations.

Z. Pipe Guides

1. Type 35 guides using, steel, reinforced polytetrafluoroethylene (PTFE) or graphite slides shall be provided where required to allow longitudinal pipe movement. Lateral restraints shall be provided as required. Slide materials shall be suitable for the system operating temperatures, atmospheric conditions, and bearing loads encountered.

AA. Steel Slides

1. Where steel slides do not require provisions for restraint of lateral movement, an alternate guide method may be used. On piping 4-in and larger, a Type 39 saddle shall be used. On piping under 4-in , a Type 40 protection shield may be attached to the pipe or insulation and freely rest on a steel slide plate.

BB. High Temperature Guides with Cradles

1. Where there are high system temperatures and welding to piping is not desirable, then the Type 35 guide shall include a pipe cradle, welded to the guide structure and strapped securely to the pipe. The pipe shall be separated from the slide material by at least 4-in , or by an amount adequate for the insulation, whichever is greater.

CC. Multiple Pipe Runs

1. In the support of multiple pipe runs on a common base member, a clip or clamp shall be used where each pipe crosses the base support member.
2. Spacing of the base support members shall not exceed the hanger and support spacing required for an individual pipe in the multiple pipe run.

DD. Structural Attachments

1. Attachment to building structure concrete and masonry shall be by cast-in concrete inserts, built-in anchors, or masonry anchor devices. Inserts and anchors shall be applied with a safety factor not less than 5. Supports shall not be attached to metal decking.
2. Masonry anchors for overhead applications shall be constructed of ferrous materials only.
3. Structural steel brackets required to support piping, headers, and equipment, but not shown, shall be provided under this section.

EE. Pipe Alignment Guides

1. Pipe alignment guides shall be provided where indicated for expansion loops, offsets, and bends and as recommended by the manufacturer for expansion joints,

not to exceed 5 ft on each side of each expansion joint, and in lines 4-in or smaller not more than 2 ft on each side of the joint.

FF. Pipe Anchors

1. Anchors shall be provided wherever necessary or indicated to localize expansion or to prevent undue strain on piping. Anchors shall consist of heavy steel collars with lugs and bolts for clamping and attaching anchor braces, unless otherwise indicated. Anchor braces shall be installed in the most effective manner to secure the desired results using turnbuckles where required. Supports, anchors, or stays shall not be attached where they will injure the structure or adjacent construction during installation or by the weight of expansion of the pipeline. Where pipe and conduit penetrations of vapor barrier sealed surfaces occur, these items shall be anchored immediately adjacent to each penetrated surface, to provide essentially zero movement within penetration seal. Detailed drawings of pipe anchors shall be submitted for approval before installation.

GG. Building Surface Penetrations

1. Sleeves shall not be installed in structural members except where indicated or approved. Sleeves in nonload bearing surfaces shall be galvanized sheet metal, conforming to ASTM A653/A653M, Coating Class G-90, 20 gauge. Sleeves in load bearing surfaces shall be uncoated carbon steel pipe, conforming to ASTM A53/A53M, Schedule 30. Sealants shall be applied to moisture and oil-free surfaces and elastomers to not less than ½-in depth. Sleeves shall not be installed in structural members.

HH. Refrigerated Space

1. Refrigerated space building surface penetrations shall be fitted with sleeves fabricated from hand-lay-up or helically wound, fibrous glass reinforced polyester or epoxy resin with a minimum thickness equal to equivalent size Schedule 40 steel pipe. Sleeves shall be constructed with integral collar or cold side shall be fitted with a bonded slip-on flange or extended collar. In the case of masonry penetrations where sleeve is not cast-in, voids shall be filled with latex mixed mortar cast to shape of sleeve and flange/external collar type sleeve shall be assembled with butyl elastomer vapor barrier sealant through penetration to cold side surface vapor barrier overlap and fastened to surface with masonry anchors. Integral cast-in collar type sleeve shall be flashed with not less than 4-in of cold side vapor barrier overlap of sleeve surface. Normally noninsulated penetrating round surfaces shall be sealed to sleeve bore with mechanically expandable seals in vapor tight manner and remaining warm and cold side sleeve depth shall be insulated with not less than 4-in of foamed-in-place rigid polyurethane or foamed-in-place silicone elastomer. Vapor barrier sealant shall be applied to finish warm side insulation surface. Warm side of penetrating surface shall be insulated beyond vapor barrier sealed sleeve insulation for a distance which prevents condensation. Wires in refrigerated space surface penetrating conduit shall be sealed with vapor barrier plugs or compound to prevent moisture migration through conduit and condensation therein.

II. General Service Areas

1. Each sleeve shall extend through its respective wall, floor, or roof, and shall be cut flush with each surface. Pipes passing through concrete or masonry wall or concrete floors or roofs shall be provided with pipe sleeves fitted into place at the time of construction. Sleeves shall be of such size as to provide a minimum of ¼-in

all-around clearance between bare pipe and sleeves or between jacketed-insulation and sleeves.

2. Except in pipe chases or interior walls, the annular space between pipe and sleeve or between jacket over-insulation and sleeve shall be sealed in accordance with Section 07 92 13 - Elastomeric Joint Sealants.

JJ. Waterproof Penetrations

1. Pipes passing through roof or floor waterproofing membrane shall be installed through a 17 oz copper sleeve, or a 0.032-in thick aluminum sleeve, each within an integral skirt or flange.
2. Flashing sleeve shall be suitably formed, and skirt or flange shall extend not less than 8-in from the pipe and be set over the roof or floor membrane in a troweled coating of bituminous cement. The flashing sleeve shall extend up the pipe a minimum of 2-in above the roof or floor penetration. The annular space between the flashing sleeve and the bare pipe or between the flashing sleeve and the metal-jacket-covered insulation shall be sealed as indicated. Penetrations shall be sealed by either one of the following methods.
3. Waterproofing Clamping Flange: Pipes up to and including 10-in in diameter passing through roof or floor waterproofing membrane may be installed through a cast iron sleeve with caulking recess, anchor lugs, flashing clamp device, and pressure ring with brass bolts. Waterproofing membrane shall be clamped into place and sealant shall be placed in the caulking recess.
4. Modular Mechanical Type Sealing Assembly: In lieu of a waterproofing clamping flange and caulking and sealing of annular space between pipe and sleeve or conduit and sleeve, a modular mechanical type sealing assembly may be installed. Seals shall consist of interlocking synthetic rubber links shaped to continuously fill the annular space between the pipe/conduit and sleeve with corrosion protected carbon steel bolts, nuts, and pressure plates. Links shall be loosely assembled with bolts to form a continuous rubber belt around the pipe with a pressure plate under each bolt head and each nut. After the seal assembly is properly positioned in the sleeve, tightening of the bolt shall cause the rubber sealing elements to expand and provide a watertight seal between the pipe/conduit and the sleeve. Each seal assembly shall be sized as recommended by the manufacturer to fit the pipe/conduit and sleeve involved. The Contractor electing to use the modular mechanical type seals shall provide sleeves of the proper diameters.

KK. Escutcheons

1. Finished surfaces where exposed piping, bare or insulated, pass through floors, walls, or ceilings, except in boiler, utility, or equipment rooms, shall be provided with escutcheons. Where sleeves project slightly from floors, special deep-type escutcheons shall be used. Escutcheon shall be secured to pipe or pipe covering.

LL. Access Panels

1. Access panels shall be provided for all concealed valves, vents, controls, and items requiring inspection or maintenance. Access panels shall be of sufficient size

and located so that the concealed items may be serviced and maintained or completely removed and replaced.

MM. Identification Tags

1. Provide identification tags made of brass, engraved laminated plastic or engraved anodized aluminum indicating service and item number on all valves and dampers. Tags shall be 1 3/8-in minimum diameter and marking shall be stamped or engraved. Indentations shall be black for reading clarity. Tags shall be attached to valves with No. 12 AWG copper wire, chrome-plated beaded chain or plastic straps designed for that purpose.

3.03 CLEANING AND ADJUSTING

- A. Clean uncontaminated system(s) by evacuation and purging procedures currently recommended by refrigerant and refrigerant equipment manufacturers, and as specified herein, to remove small amounts of air and moisture. Systems containing moderate amounts of air, moisture contaminated refrigerant, or any foreign matter shall be considered contaminated systems. Restoring contaminated systems to clean condition including disassembly, component replacement, evacuation, flushing, purging, and re-charging, shall be performed using currently approved refrigerant and refrigeration manufacturer's procedures. Restoring contaminated systems shall be at no additional cost to the Government as determined by the Contracting Officer. Water shall not be used in any procedure or test.

3.04 REFRIGERANT PIPING TESTS

A. General

1. After all components of the refrigerant system have been installed and connected, subject the entire refrigeration system to pneumatic, evacuation, and startup tests as described herein. Submit a schedule, at least 2 weeks prior to the start of related testing, for each test. Identify the proposed date, time, and location for each test. Conduct tests in the presence of the Contracting Officer. Water and electricity required for the tests will be furnished by the Government. Provide all material, equipment, instruments, and personnel required for the test. Provide the services of a qualified technician, as required, to perform all tests and procedures indicated herein.
2. SYSTEMS. Submit 6 copies of the tests report in bound 8 1/2 by 11-in booklets documenting all phases of the tests performed. The report shall include initial test summaries, all repairs/adjustments made, and the final test results.

B. Preliminary Procedures

1. Prior to pneumatic testing, equipment which has been factory tested and refrigerant charged as well as equipment which could be damaged or cause personnel injury by imposed test pressure, positive or negative, shall be isolated from the test pressure or removed from the system. Safety relief valves and rupture discs, where not part of factory sealed systems, shall be removed and openings capped or plugged.

C. Pneumatic Test

1. Pressure control and excess pressure protection shall be provided at the source of test pressure. Valves shall be wide open, except those leading to the atmosphere. Test gas shall be dry nitrogen, with minus 70 deg F dewpoint and less than 5 ppm oil. Test pressure shall be applied in two stages before any refrigerant pipe is insulated or covered. First stage test shall be at 10 psi with every joint being tested with a thick soap or color indicating solution. Second stage tests shall raise the system to the minimum refrigerant leakage test pressure specified in ANSI/ASHRAE 15 & 34 with a maximum test pressure 25 percent greater. Pressure above 100 psig shall be raised in 10 percent increments with a pressure acclimatizing period between increments. The initial test pressure shall be recorded along with the ambient temperature to which the system is exposed. Final test pressures of the second stage shall be maintained on the system for a minimum of 24 hours. At the end of the 24 hour period, the system pressure will be recorded along with the ambient temperature to which the system is exposed. A correction factor of 0.3 psi will be allowed for each degree change between test space initial and final ambient temperature, plus for increase and minus for a decrease. If the corrected system pressure is not exactly equal to the initial system test pressure, then the system shall be investigated for leaking joints. To repair leaks, the joint shall be taken apart, thoroughly cleaned, and reconstructed as a new joint. Joints repaired by caulking, remelting, or back-welding/brazing shall not be acceptable. Following repair, the entire system shall be retested using the pneumatic tests described above. The entire system shall be reassembled once the pneumatic tests are satisfactorily completed.

D. Evacuation Test

1. Following satisfactory completion of the pneumatic tests, the pressure shall be relieved and the entire system shall be evacuated to an absolute pressure of 0.006 PSI. During evacuation of the system, the ambient temperature shall be higher than 35 deg F. No more than one system shall be evacuated at one time by one vacuum pump. Once the desired vacuum has been reached, the vacuum line shall be closed and the system shall stand for 1 hour. If the pressure rises over 0.01 PSI after the 1 hour period, then the system shall be evacuated again down to 0.06 PSI and let set for another 1 hour period. The system shall not be charged until a vacuum of at least 0.01 PSI is maintained for a period of 1 hour without the assistance of a vacuum line. If during the testing the pressure continues to rise, check the system for leaks, repair as required, and repeat the evacuation procedure. During evacuation, pressures shall be recorded by a thermocouple-type, electronic-type, or a calibrated-micrometer type gauge.

E. System Charging and Startup Test

1. Following satisfactory completion of the evacuation tests, the system shall be charged with the required amount of refrigerant by raising pressure to normal operating pressure and in accordance with manufacturer's procedures. Following charging, the system shall operate with high-side and low-side pressures and corresponding refrigerant temperatures, at design or improved values. The entire system shall be tested for leaks. Fluorocarbon systems shall be tested with halide torch or electronic leak detectors.

F. Refrigerant Leakage

1. If a refrigerant leak is discovered after the system has been charged, the leaking portion of the system shall immediately be isolated from the remainder of the system and the refrigerant pumped into the system receiver or other suitable

container. Under no circumstances shall the refrigerant be discharged into the atmosphere.

G. Contractor's Responsibility

1. At all times during the installation and testing of the refrigeration system, take steps to prevent the release of refrigerants into the atmosphere. The steps shall include, but not be limited to, procedures which will minimize the release of refrigerants to the atmosphere and the use of refrigerant recovery devices to remove refrigerant from the system and store the refrigerant for reuse or reclaim. At no time shall more than 3 ounces of refrigerant be released to the atmosphere in any one occurrence. Any system leaks within the first year shall be repaired in accordance with the requirements herein at no cost to the Government including material, labor, and refrigerant if the leak is the result of defective equipment, material, or installation.

END OF SECTION

SECTION 23 34 00 – HVAC FANS

PART 1 -- GENERAL

1.01 SUMMARY

- A. Provide fans, blowers, ventilators, and appurtenances, complete and operable, as indicated in accordance with the Contract Documents.
- B. Where 2 or more fans, blowers, ventilators or appurtenances of the same type or size are required, they shall be furnished by the same manufacturer.

1.02 CONTRACTOR SUBMITTALS

- A. Furnish submittals in accordance with the requirements of Section 01 33 00 – Submittal Procedures.
- B. Shop Drawings
 - 1. Submit certified fan curves for each fan.
- C. O&M Data
 - 1. Submittals shall include operation, maintenance, and inspection data, replacement part numbers and availability, and service depot location and telephone number.

1.03 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

A. Reference Specifications

01 33 00	Submittal Procedures
03 30 00	Cast-in-Place Concrete
09 96 00	High Performance Coatings
26 05 10	Low-Voltage Electric Motors

B. Reference Standards

Air Moving and Conditioning Association (AMCA)	
AMCA 300-14	Reverberant Room Method for Sound Testing of Fans
Standard 99	Standards Handbook, Reverberant Room Method for Sound Testing of Fans.
Standard 210	Laboratory Methods of Testing Fans for Rating
American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE)	
	HVAC Applications chapter in "Seismic Restraint Design"
	Spec 01 33 17 – Seismic and Wind Design Criteria
Institute of Electrical and Electronics Engineers, Inc. (IEEE)	
112	Standard Test Procedure for Polyphase Induction Motors and Generators
National Electrical Manufacturers Association (NEMA)	

HVAC FANS

MG 112.53a	Motors and Generators
National Fire Protection Association (NFPA)	
70	National Electric Code (NEC)
90A	Standard for the Installation of Air Conditioning and Ventilating Systems
Occupational Safety and Health Act (OSHA)	
Underwriters Laboratories Inc. (UL)	
	Product Directories

1.04 MOTORS

- A. All motors shall conform to the latest IEEE and NEMA requirements for mechanical and electrical characteristics, including service factors.
- B. Motors shall be in accordance with the requirements of Section 26 05 10 – Low-Voltage Electric Motors.
- C. Each motor shall bear the manufacturer's nameplate with complete motor data.
- D. Each motor shall be of ample size and construction to carry continuously all loads which might be imposed by the piece of equipment it drives throughout the full range of operation of the equipment, and the maximum motor loading shall in all cases be less than or equal to the nameplate horsepower rating, exclusive of the service factor.
- E. All 2-speed motors shall be 2-winding motors.

PART 2 -- PRODUCTS

2.01 CEILING TOILET EXHAUST FANS, DIRECT-DRIVE

- A. Provide ceiling toilet exhaust fans as indicated.
- B. Fans shall be of the forward-curved, direct-drive type.
- C. The fan housing and scroll shall be constructed of corrosion-resistant galvanized steel.
- D. Grilles shall be constructed of white high-impact polystyrene (non-yellowing) with 2 attachment screws, and shall provide an 85-percent free area.
- E. Provide the fan with a round-curved outlet connection.
- F. Fan Wheels
 - 1. Fan wheels shall be of the forward-curved type and shall be constructed of calcium carbonate-filled polypropylene.
 - 2. Wheels shall be dynamically balanced for vibration-free operation.
- G. The integral backdraft damper shall be chatterproof.
- H. The entire fan, motor, and wheel assemblies shall be removable without disturbing the housing.

I. Fan Motors

1. Provide motors with thermal overload protection sized to match fan loads.
2. Nominal fan motor speeds shall not exceed 1550 RPM.
3. Fan motors shall be suitably grounded and mounted on vibration isolators.
4. Fan motor housing shall be complete with mounting angles.

J. Fans shall meet requirements as scheduled on drawings.

K. Manufacturer, or Equal

1. Greenheck, Model SP-A125
2. Cook
3. PennBarry

2.02 INLINE EXHAUST FANS

A. Provide inline exhaust fans as indicated.

B. Provide fans of the centrifugal, direct-driven, inline type.

C. Fan housing shall be of square design aluminum construction, and shall include square duct mounting collars and removable access panels.

D. The fan wheel shall be of the centrifugal backward inclined type, of aluminum construction, and shall include a wheel cone matched to the inlet cone.

E. The fan motor shall be of the heavy-duty ball bearing type, and provided with a motor guard.

F. Fans shall meet the performance requirements listed on drawings.

G. Manufacturer, or Equal

1. Greenheck, Model SQ
2. Cook
3. PennBarry

PART 3 -- EXECUTION

3.01 INSTALLATION

A. Fans, blowers, ventilators, and hoods shall be installed in strict accordance with the manufacturer's recommendations.

END OF SECTION

SECTION 23 70 10 – AIR CONDITIONING EQUIPMENT

PART 1 -- GENERAL

1.01 THE SUMMARY

- A. Provide air conditioning units and appurtenances, complete and operable, in accordance with the Contract Documents.
- B. Where two or more air conditioning units or appurtenances of the same type or size are required, they shall be furnished by the same Manufacturer.

1.02 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

A. Reference Specifications

01 33 00	Submittal Procedures
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B. Reference Standards

Air-Conditioning, Heating and Refrigeration Institute (AHRI)	
AHRI 410	Forced-Circulation Air Cooling and Air Heating Coils
AHRI 430	Standard for Application of Central-Station Air Handling Units
AHRI 260	Sound Rating of Ducted Air Moving and Conditioning Equipment
Air Movement and Control Association International, Inc. (AMCA)	
AMCA 99	Standard Handbook
AMCA 210	Laboratory Methods of Testing Fans for Rating Purposes
AMCA 300	Test Code for Sound Rating Air Moving Devices
AMCA 301	Method of Publishing Sound Ratings for Air Moving Devices
AMCA 500	Test Methods for Louvers, Dampers, and Shutters
AMCA 611-95	Methods of Testing Airflow Measurement Stations for Rating
American Bearing Manufacturers Association (ABMA)	
ABMA STD 9	Load Ratings and Fatigue Life for Ball Bearings
American National Standards Institute (ANSI)	
American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE)	
ASHRAE 52.1/52.2	Method of Testing General Ventilation Air Cleaning Devices for Removal Efficiency by Particle Size
ASHRAE 62	Ventilation for Acceptable Indoor Air Quality
ASHRAE 90.1	Energy Standard for Buildings Except Low-Rise Residential Buildings
Building Automation Solutions (BAS)	
Canadian Standards Association (CSA)	
Department of Energy (DOE)	
National Fire Protection Association (NFPA)	
NFPA 90A	Installation of Air Conditioning and Ventilation Systems

Sheet Metal and Air Conditioning Contractors' National Association (SMACNA)	
SMACNA	Low Pressure Duct Construction Standards
Underwriters Laboratories (UL)	
ANSI/UL 900	Test Performance of Air Filter Units

- C. The Work shall be in strict accordance with the Ohio Mechanical Code, the City of Warren, and other authorities having jurisdiction.
- D. Obtain the required certifications and become thoroughly familiar with the local codes.
- E. Obtain and pay for all necessary permits.

1.03 CONTRACTOR SUBMITTALS

- A. Furnish submittals in accordance with the requirements of Section 01 33 00 – Submittal Procedures.
- B. Product data shall include rated capacities, operating characteristics including energy efficiency, electrical characteristics, standard and optional accessories, and certified fan curves.
- C. The submittals shall include operation, maintenance, and inspection data, replacement part numbers and availability, and service depot location and telephone number.

PART 2 -- PRODUCTS

2.01 DUCTLESS SPLIT SYSTEM HEAT PUMP

- A. Provide product as scheduled on drawings per the following basis-of-design manufacturer or equal alternates listed below.
 - 1. Daikin FAQ24 + RZQ24
 - 2. Mitsubishi
 - 3. Toshiba
- B. System shall be an inverter driven heat pump split system with wall mounted indoor evaporator unit exclusively matched to an outdoor condensing unit. The condensing unit shall be a direct expansion, air cooled heat pump air conditioning system with a variable speed inverter driven compressor and horizontal discharge fan motor, using R-410A refrigerant.
- C. Outdoor Unit
- D. Indoor Unit
- E. Controls
 - 1. The system shall have factory provided controls to perform input functions necessary to operate the system.
 - 2. A full array of fault diagnostics shall be accessible via the remote controller.

3. The system shall be compatible with a BACnet MSTP network and shall be able to interface with a BMS system.

PART 3 -- EXECUTION

3.01 INSTALLATION

- A. Install air conditioning equipment in accordance with manufacturer's requirements.
- B. Install air conditioning equipment level and plumb, maintaining manufacturer's recommended service clearances and operational tolerances.
- C. Install piping, ductwork, and other appurtenances adjacent to equipment in a manner to allow requisite service and maintenance.
- D. Do not obstruct nameplate information, which shall be permanently attached on exterior of casing and be environment-resistant.
- E. Engage a factory-authorized service representative to inspect, test, and adjust installation including components, assemblies, and connections.

END OF SECTION

SECTION 23 82 10 – ELECTRIC HEATING EQUIPMENT

PART 1 -- GENERAL

1.01 SUMMARY

- A. The Contractor shall provide the electric heaters, and appurtenances, complete and operable, as indicated in accordance with the Contract Documents.
- B. Where 2 or more heaters or appurtenances of the same type or size are required, they shall be furnished by the same manufacturer.

1.02 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

A. Reference Specifications

01 33 00	Submittal Procedures
23 05 00	Common Work Results for HVAC
26 05 10	Low-Voltage Electric Motors

B. Reference Standards

Underwriters Laboratories (UL)
National Electrical Manufacturers Association (NEMA)
American Society of Mechanical Engineers (ASME)

1.03 CONTRACTOR SUBMITTALS

- A. Submittals shall be furnished in accordance with the requirements of Section 01 33 00 – Submittal Procedures.
- B. The submittals shall include operation, maintenance, and inspection data, replacement part numbers and availability, and service depot location and telephone number.

1.04 QUALITY

A. Codes and Permits

- 1. The Work shall be in strict accordance with the Ohio Mechanical Code, the City of Warren, and any other authorities having jurisdiction.
- 2. The Contractor shall have the required certification and be thoroughly familiar with the local codes.
- 3. The Contractor shall obtain and pay for necessary permits.

B. Diligent Care

- 1. Care shall be taken at all times to protect floors, stairways, and walls during the make-up, erection of piping and placing of equipment.
- 2. The Contractor shall remove all stains and repair all damage before final acceptance of the Work.

C. Materials

1. The materials used in connection with the electric heating system work shall:
 - a. be new;
 - b. be free from flaws and defects;
 - c. be fully equal to the quality specified; and,
 - d. conform to the requirements of applicable specifications and standards.
2. If during the construction of the Project the Engineer finds materials that have identifying marks removed, or lacking such marks completely, such items may be rejected until the Contractor has shown proof that said items conform to the indicated requirements, where the adequacy and extent of such proof shall be determined by the Engineer.

PART 2 -- PRODUCTS

2.01 GENERAL

- A. Motors shall be in conformance with the requirements of Section 26 05 10 – Low-Voltage Electric Motors.
- B. The electrical system and components for electric heating systems shall be in conformance with the requirements of Section 23 05 00 – Common Work Results for HVAC.

2.02 ELECTRIC UNIT HEATERS

A. General

1. Electric unit heaters shall be of the horizontal or vertical type as indicated, and shall be provided complete with motor, fan, wire guard, heating element, casing, vibration isolators and support brackets.
2. The capacities of the units, the mounting, whether recessed, semi-recessed, or surface-mounted, and other data shall be as scheduled.
3. The units shall be UL-listed and shall meet the requirements of the National Electric Code.
4. The units shall be provided with their own wall or ceiling mounting brackets.

B. Casings

1. The fan casings shall be steel reinforced in order to provide a suitable support for the heating element and for attachment of the support brackets.
2. Casings shall be finished with factory finish.

C. Fans and Motors

1. Fans shall be of the multi-blade propeller type, and shall be directly connected to the motor shaft or centrifugal fan.
2. Motor units shall be statically and dynamically balanced.
3. Motors shall be especially designed for unit operation.
4. Fan shafts shall be equipped with self-aligning ball or roller bearings, and shall extend a sufficient length to receive the fan hub.
5. The fan shall be keyed and locked to the fan shaft.
6. The fan and motor unit shall be mounted on vibration isolators in order to prevent noise.

D. Electrical

1. The electric heating bank shall consist of metal sheath aluminum-finned heating elements.
2. Provide automatic reset thermal over-heat protection of the linear capillary type and wired for instantaneous de-energizing.'
3. The heating bank shall be provided with protective air inlet louvers.
4. Provide low-voltage control transformers.
5. The heaters shall be provided with power disconnect switches (field installed kits), and a built-in thermostat unless otherwise indicated.

E. Electric Unit Heaters Manufacturer, or Equal

1. Q-Mark IUH
2. Reznor
3. Chromalox

2.03 ELECTRIC WALL HEATERS

- A. Provide electric wall heaters as indicated.
- B. The capacities of the units, the mounting, whether recessed, semi-recessed, or surface-mounted, and other data shall be as scheduled.
- C. The front louvered grille shall be constructed of 18-gauge steel.
- D. The heaters shall be provided with permanently lubricated bearings and a totally enclosed shaded pole type fan motor.
- E. The heaters shall be provided with a built-in adjustable thermostat, control transformers, a built-in disconnect switch, and thermal overloads.
- F. Electric Wall Heater Manufacturers, or Equal
 1. Q-Mark AWH

ELECTRIC HEATING EQUIPMENT

2. Chromalox

3. Indeeco

PART 3 -- EXECUTION

3.01 INSTALLATION

- A. The electric heating equipment shall be installed by a qualified installer in strict accordance with the manufacturer's recommendations.

END OF SECTION

SECTION 26 00 10 – ELECTRICAL GENERAL REQUIREMENTS

PART 1 -- GENERAL

1.01 SUMMARY

A. Section Includes

1. The work under this Contract consists of a complete and operational electrical system as detailed in the Contract Drawings and as specified herein.
2. The intent of the Contract Documents is to include all labor, products, components and services necessary to complete the work, tested, commissioned, and placed into full operation.
3. The work of this Section is required for installation, testing and operation of electrically driven equipment provided under Specifications in other Divisions.
4. The work of this Section is required for installation, testing and operation of Instrumentation and Control Systems provided under the applicable Sections of Division 40.
5. The Contractor shall coordinate the work of Division 26 with the work of other Divisions of these Specifications to provide a coordinated installation.
6. The provisions of this Section shall apply to all Sections in Division 26, except as otherwise indicated.
7. This section of the specification forms part of the contract documents and is to be read, interpreted, and coordinated with all other parts.

1.02 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

A. Definitions

1. The word “supply” as used in these specifications shall be taken to mean that the so noted equipment is to be purchased, assembled and shipped to the site, including all costs associated with insurance and handling until the Contractor receives written acceptance at the site by the Engineer. The Contractor is responsible to ensure the Supplier of the equipment confirms the functionality of equipment at site prior to the commissioning of the system. Where an item is noted as supplied by the Owner, by others, or by another Division, the electrical work of mounting, connecting and commissioning the item shall be included in the Contract unless specifically noted otherwise.
2. The word “provide” as used in these specifications shall be taken to mean that the so noted equipment is to be supplied, mounted, connected, adjusted, tested and placed into service by this Contract.
3. The word “reviewed” as used in these specifications shall be taken to mean that the so noted equipment is to be reviewed for conformance to the Contract Documents by the Engineer, prior to fabrication.

4. The word “install” means all work and material necessary to place the specified item into full operation, securely fastened and to give a presentable finished appearance. “Install” also includes all necessary connections, wiring, testing and commissioning. Where indicated, this Contract shall require the Contractor to install equipment that is supplied by Others.
5. The word “coordinate” means to make all arrangements directly with the Owner, Engineer, agencies, equipment suppliers, trades, sub-trades and individuals; confirm schedules; be in attendance at the time work is carried out; and take full responsibility for having the work carried out correctly and in a timely manner to meet the construction schedule.

B. Reference Standards

1. The following standards are referenced in this section and throughout Division 26. The edition/revision in effect at the time of bidding shall apply, unless otherwise specified.
 - a. InterNational Electrical Testing Association (NETA)
 - b. National Electrical Manufacturers Association (NEMA)
 - c. Occupational Health and Safety Act (OHSA).
 - d. Institute of Electrical and Electronics Engineers (IEEE)
 - e. American National Standards Institute (ANSI)
 - f. National Fire Protection Association (NFPA)
2. Electrical equipment shall be listed by and shall bear the label of Underwriters' Laboratories, Inc. (UL) or a Nationally Recognized Testing Laboratory (NRTL) acceptable to the local code enforcement agency having jurisdiction.
3. Installation of electrical equipment and materials shall comply with OSHA Safety and Health Standards (29 CFR 1910 and 29 CFR 1926, as applicable), state building standards, and applicable local codes, amendments and regulations.
4. Where the requirements of the specifications conflict with UL/NRTL, NEMA, NFPA, or other applicable codes or standards, the more stringent requirements shall govern.

C. Reference Specifications

01 33 00	Submittal Procedures
01 33 17	Structural Design, Support and Anchorage
01 45 00	Quality Control
01 60 00	Products, Materials, Equipment and Substitutions
01 75 00	Equipment Testing and Plant Startup
01 77 00	Project Closeout
01 79 00	Owner Staff Training

ELECTRICAL GENERAL REQUIREMENTS

Division 26 – All Sections	Electrical (All Sections)
Division 40- Various	Instrumentation and Controls (All Applicable Sections)

D. Reference Codes

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)	
NFPA 70	National Electrical Code, 2023 Edition

1.03 CODES, PERMITS, AND INSPECTIONS

- A. The installation shall comply with the requirements of the edition of the National Electrical Code and the electrical by-laws and amendments as adopted by the local Authority Having Jurisdiction (AHJ). Where a local or regional AHJ has not adopted a specific electrical code, the latest version of the National Electrical Code shall apply.
- B. Obtain all permits required and pay inspection fees according to the General Conditions. Take out all permits prior to beginning the work.
- C. Coordinate all inspections with the AHJ and correct all identified installation issues to the satisfaction of the AHJ. Re-work associated with corrective actions identified by AHJ inspections, the Owner and Engineer; failure to meet applicable codes; and failure to meet requirements of the contract documents shall be corrected at no additional cost to the Owner.
- D. After completion of the work, furnish to the Engineer the certificate(s) of final inspection and approval from the local AHJ.

1.04 SITE CONDITIONS

A. Protection

1. Provide physical protection and energize space heaters (as applicable) for all equipment to protect from damage due to ambient conditions during storage and prior to energization. Protection and storage shall be provided in strict accordance with the manufacturers' and suppliers' requirements.
2. Protect finishes and nameplates on equipment to prevent defacing.
3. Repair, restore or replace damaged, corroded, and rejected items. Where damaged equipment cannot be repaired to a "like new" condition in the opinion of the Owner or Engineer, the equipment shall be replaced at no additional cost to the Owner.

B. Job Conditions

1. Schedule work which will cause interference or interruption in advance with Owner, Engineer, authorities having jurisdiction, and all affected trades. Shutdowns shall be performed in strict accordance with the requirements of the General Conditions and the Division 1 specifications.
2. Examine the Contract Documents to determine how other work will affect the execution of electrical work.

ELECTRICAL GENERAL REQUIREMENTS

3. Where any material, equipment or system components are installed differently from that shown, show such differences clearly and neatly, using ink or indelible pencil.
4. Prior to substantial completion, submit record documents in accordance with the requirements of the individual Sections of Division 26, Section 01 33 00 – Submittal Procedures and Section 01 77 00 – Project Closeout.

C. Area Classifications

1. Electrical equipment shall be approved and listed for use in the area classification in which it is used. Area classifications shall be defined by the NEMA enclosure definitions described in NEMA 250 – Enclosures for Electrical Equipment (1,000 Volts Maximum).
2. Area classifications for electrical work specifically indicated in other Sections shall comply with the requirements of this Section.
3. Area classifications for electrical work shall be as follows, except where specifically indicated otherwise on the drawings:

AREA	NEMA ENCLOSURE CLASSIFICATION					
	1	4X	7	9	12	Notes
Electrical Room	X					
Outdoors		X				

4. Area classifications for electrical work other than specifically indicated above shall default to NEMA 4X.

D. Field Verifications

1. Visit the Site before submitting a Bid to become better acquainted with the work of this Contract.
2. The lack of knowledge will not be accepted as justification for extra compensation to perform the work.
3. The Contractor shall be responsible for identifying available existing circuit breakers in panelboards, motor control centers and switchboards for the intended use as required.
4. The Contractor shall be responsible for field verifying the available space in switchgear and switchboards to integrate new power circuit breakers as indicated.
5. The cost for the above verifications shall be included as part of the work.

1.05 ACTION SUBMITTAL PROCEDURES

- A. Submit Shop Drawings, Product Data, and samples in accordance with Section 01 33 00 – Submittal Procedures and this Section.
- B. Shop Drawings

1. Shop Drawings submitted for review shall be reviewed by Contractor for conformance with design intent, relevant Specifications and coordinated with other divisions' Submittal Procedures. Shop drawings not signed and reviewed by Contractor will be returned "not reviewed".
2. Indicate details of construction, dimensions, capacities, weights and electrical performance characteristics of equipment or material.
3. Highlight or otherwise indicate options or specific items to be provided. Cross out items not intended to be provided. Drawings or data indicating "optional" or "as required" will not be accepted.
4. Include wiring, line and schematic diagrams applicable to this project. Generic wiring diagrams that do not apply to the project shall not be included and are not acceptable. Include wiring drawings or diagrams showing interconnection with other equipment and with work of other divisions.
5. Content:
 - a. Shop Drawing submittal title sheet.
 - b. Data shall be specific and technical.
 - c. Identify each piece of equipment with appropriate project-specific equipment tag.
 - d. Information shall include all scheduled data.
 - e. Advertising and commercial presentation literature will be rejected.
 - f. The project and equipment designations shall be identified on each document.
 - g. Information shall be provided in Imperial units.
 - h. The Shop Drawings / Product Data shall include as a minimum:
 - 1) Catalog cuts for all equipment and materials identifying the equipment manufacturer(s), catalog and model numbers, options, etc.
 - 2) Bill of materials.
 - 3) Dimensioned construction drawings with plans, elevations and sections showing size, arrangement, and necessary clearances, with all equipment weights and mounting point loads, and all approvals, certifications, listing/labelling, and manufacturing standards which apply.
 - 4) Mounting arrangements showing access clearances and ventilation requirements. Include dimensioned areas for cable/conduit entries and access plates.
 - 5) Detailed drawings of bases, supports and anchor bolts. Provide seismic installation data and instructions for installation.

- 6) Control explanation and complete ladder schematics and interconnection wiring diagrams. Provide details on interconnections, terminal and wire numbering and conductor sizing.
 - 7) Types of materials and finish
 - 8) Nameplate information including mounting locations, materials, font type/size, background and text colors, and text for each nameplate.
 - 9) Temperature ratings and limitations, as applicable.
 - 10) Electrical ratings including, but not limited to: Operating voltage, current, number of phases, frequency, and short circuit current ratings.
 - 11) Grounding requirements.
 - 12) Factory Test information.
 - 13) Spare parts information.
 - i. Operation and maintenance training information and training syllabus. Provide in accordance with Section 01 79 00 – Owner Staff Training.
 - j. Equipment supports shall be designed and submitted for approval, meeting the requirements of Section 01 33 17 - Structural Design, Support and Anchorage.
6. Submission format:
- a. Provide in accordance with Section 01 33 00 – Submittal Procedures, with the following additional requirements:
 - 1) Text size shall be 10 point minimum. Smaller font sizes or unreadable text shall be grounds for rejection.
 - 2) Text shall be in English.
 - 3) Electronic Submittal Procedures shall be in bookmarked, using pdf (portable document format) file structure. PDF's of drawings and other shop drawing information shall be generated from the original electronic documents. Scanned pdf documents shall be limited to equipment catalog cuts, provided that they are clearly legible.
 - 4) Markings and clarifications in the Submittal Procedures by the Contractor or Supplier shall be in colors other than red, as this is reserved for Engineer/Owner review markings.
7. Coordination:
- a. Where electrical equipment requires support or backing or interconnection with other trades (mechanical connections, etc.), the Shop Drawings shall also be circulated for review to the other relevant Subcontractor(s) prior to submission to the Engineer.

1.06 SUBMITTAL PROCEDURES

A. Operation and Maintenance Data

1. Submittal Procedures Provide operation and maintenance data for incorporation into operation and maintenance (O&M) manuals. Manuals shall be prepared and submitted in accordance with Section 01 77 00 – Project Closeout and Section 01 33 00 – Submittal Procedures. The O&M manuals shall describe the equipment in full and shall include the following major items:
 - a. Operating instructions and start-up procedures, including receiving and installation requirements. Where installed in seismic areas, include specific requirements for seismic installations.
 - b. Maintenance instructions listing preventive and corrective maintenance procedures and frequency of maintenance. Corrective maintenance procedures shall identify the most probable failures and the appropriate repairs. Test measurement levels shall be referenced to specific test points on the installed equipment.
 - c. Details of design elements, construction features, component function and maintenance requirements, to permit effective operation, maintenance, repair, modification, extension and expansion of any portion or feature of installation.
 - d. Spare parts data shall be furnished for each item of material and equipment specified. The data shall include a complete list of parts and supplies with current source of supply. A list and itemized breakdown (with current pricing) of spare parts recommended for stocking shall be furnished. The parts selected shall be those which, in the manufacturer's judgment, will be involved in the majority of maintenance procedures expected.
 - e. Equipment fabrication drawings, one-line diagrams, schematic diagrams and connection diagrams. Wiring and schematic diagrams must be specific to each individual piece of equipment and be detailed with as-built wire/cable tags and termination information. Generic documentation is not acceptable.
 - f. Catalog cuts and technical manuals for all components of the system, with specific model numbers clearly identified, and including technical data, product data; supplemented by bulletins, component illustrations, exploded views, technical descriptions of items, and parts lists. Advertising and sales literature are not acceptable.
 - g. Copy of all guarantees and warranties issued for the various items of equipment, showing all dates of expiration.
 - h. Copies of all testing and commissioning results.
 - i. Copies of all “as-left” adjustable and programmable settings. In addition, provide electronic files of programmable settings for devices that can be programmed using such settings files.
 - j. Final copies of all shop drawings, incorporating manufacturing and field “as-built” changes.

- k. Record (as-built) Contract Drawings updated to show revisions to the electrical work when different from the original Contract Drawings. Prepare by obtaining new, clean sets of Contract Drawings from the Owner, and pay all costs for the same.
 - l. Names and addresses of local suppliers for items included in maintenance manuals.
 - 2. The O&M manuals shall be formatted in accordance with Division 1 requirements. Where specific formatting is not included in Division 1, the O&M manuals shall have tabs for the following major sections:
 - a. Title page (in plastic cover).
 - b. Comprehensive description of the operation of the systems, including the function of each item of equipment within the system.
 - c. Detailed instructions for the normal maintenance of all systems and equipment installed including procedures and frequency of operational checks and service and troubleshooting instructions.
 - d. Local source of supply for each item of equipment.
 - e. Wiring and control diagrams.
 - f. Spare parts list.
 - g. Copies of guarantees and certificates.
 - h. Manufacturer's maintenance manuals and final as-built shop drawings.
 - 3. Submit a single draft copy of each O&M Manual to the Engineer for review thirty (30) days prior to start-up of the systems and equipment covered by the manual. Once approved, provide the remaining copies of the manuals to the Owner for distribution.
 - 4. Electronic O&M Manuals shall be in a bookmarked portable document format (PDF). Manuals without bookmarks will be rejected.
- B. Record Documentation
 - 1. Submittal Procedures Provide project as-built documents as specified in Section 01 77 00 – Project Closeout and as further called for in this division.
 - 2. During the construction period, keep on site a clean set of contract drawings marked up to reflect the "As-Built" state of all contract drawings, for examination by the Owner and/or Engineer on a regular basis. Include elevations and detailed locations of buried services, conduit and cable tray systems, junction boxes and pull boxes.
 - 3. Upon completion of commissioning of the electrical equipment, the Contractor shall provide the marked-up "as-built" Shop Drawings to the respective Supplier for updating the Shop Drawings for inclusion into the O&M Manuals.

4. Submit the "as-built" CAD files and full size hard copy redline markup to the Engineer prior to substantial completion of the Contract. Where the Engineer or Owner identifies items where the Contractor "as-built" drawings do not match the installation, the Contractor shall correct and resubmit all such drawings at no additional cost to the Owner prior to project final completion.
5. The Contractor will be required to sign a standard Stantec / Contractor agreement entitled "Authorization to Use CAD Drawing files". The agreement restricts the use of the Stantec CAD files to the purpose of "as-built" only and determines the editing procedures

1.07 QUALITY ASSURANCE

- A. Quality Assurance: Provide all project quality assurance/quality control in accordance with Section 01 45 00 - Quality Control.
- B. Qualifications: All electrical work shall be carried out and supervised by qualified, licensed electricians and journeypersons holding valid licenses for the type of work performed in the location(s) where the work is performed, in accordance with local requirements.
- C. Work shall be performed neatly and professionally in strict accordance with the written requirements of the equipment manufacturers and established trade procedures and practices.

1.08 PROJECT COORDINATION

- A. Check Drawings of all trades to verify space and headroom limitations for work to be installed. Coordinate work with all trades and make changes to facilitate a satisfactory installation. Make no deviations to the design intent involving extra cost to the Owner, without the Owner's written acceptance.
- B. The Drawings indicate the general location of equipment to be installed and connected. Routing of raceways and cable trays, where indicated, as general in nature. Where details are not shown on the Drawings or only shown diagrammatically, the electrical equipment shall be routed based on field conditions and customary installation practices. Raceways and cable trays shall be installed in such a way as to conserve head room and interfere as little as possible with the free use of space through which they pass. Raceways and cable trays shall be installed parallel and perpendicular to building lines. All raceways and cable trays installed above reflected ceilings shall be kept as tight as possible to beams or other limiting members at high level. All electrical installation shall be coordinated in elevation to ensure that they are concealed in the ceiling or structural space provided unless detailed otherwise on drawings.
- C. Work out jointly all interference problems on the site and coordinate all work before fabricating or installing any material or equipment. Where necessary, produce interference / coordination drawings showing exact locations of electrical systems, duct banks, or equipment within service areas, shafts and the restricted spaces. Distribute copies of the final interference / coordination drawings to the Engineer and all affected parties.

- D. Ensure that all materials and equipment fit into the allotted spaces and that all equipment can be properly serviced and replaced, if and when required. Advise the Engineer of space problems before installing any material or equipment. Demonstrate to the Owner on completion of the work that all equipment installed can be properly and safely serviced and replaced, if and when required.
- E. No extra cost will be considered for any misunderstanding of the scope of work to be performed resulting from failure to coordinate between trades.
- F. HVAC EQUIPMENT
 - 1. The Electrical Drawings provide for single and three phase power feeds to HVAC equipment under the Division 26 scope of work.
 - 2. Where starters and/or disconnect switches are provided with HVAC equipment, they shall meet the requirements of Division 26.
 - 3. Temperature control wiring is not indicated on the Electrical Drawings and shall be provided as part of the Division 23 scope of work by the Temperature Control System subcontractor. Conduits and wiring for temperature control shall meet the requirements of Division 26.
 - a. Temperature control wiring is defined as control wiring operating at 120 volts or less. Wiring to motor operated louvers and motor operated dampers shall be considered as temperature control wiring for purposes of this item.

1.09 WARRANTY

A. Manufacturer Warranty

- 1. Refer to the General Conditions and Division 1 for warranty requirements.
- 2. Provide additional warranty as per individual equipment Specifications.
- 3. Warranty of any equipment that is energized and used by the Contractor shall not commence until accepted by the Owner for beneficial use.
- 4. Temporary or trial use, of any electrical devices or equipment, shall not be construed as evidence of acceptance of the same.

1.10 UTILITY COORDINATION

- A. Contact the serving utilities and verify compliance with requirements before construction.
- B. Coordinate schedules and payments for work by utilities.
- C. The utility contact is:
- D. **Robert Wittmann**
Distribution Tech IV-Design Svcs
office: 330-841-2148 (892-2148) | cell: 330-240-4152
rwittman@firstenergycorp.com
2231 West Market Street, Warren, OH 44485 | mailstop: A-WRSB / Warren Service

- E. Where conduits and conductors are required by the utility to be larger, heavier schedule, or have greater protective coating than specified requirements, provide the larger size, heavier schedule, or greater protection.
- F. Provide electrical service(s) and service equipment as indicated and in strict accordance with the serving utility requirements.
- G. Verify and provide service conduits, fittings, transformer/switchgear pad, grounding devices, and service wires not provided by the serving utility.
- H. Verify with the utility the exact location of each service point and type of service.

PART 2 -- PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

- A. As indicated for individual equipment and material specifications.
- B. Where identified with "or equal" or "or equivalent", alternate materials of equal or superior quality may be submitted for approval in accordance with the requirements of the General Conditions and Division 1.

2.02 MATERIALS

- A. Use only new materials, apparatus, and equipment, suitable for the location(s) where installed.
- B. Provide similar items in the WORK as products of the same manufacturer.
- C. Provide equipment and materials of industrial grade standard of construction.
- D. On devices indicated to display dates, display the year as 4 digits.
- E. Temperature Ratings of Equipment Terminations
 - 1. Provide terminations and lugs rated for use with 75-degree C conductors.
 - 2. Wire sizes in the Contract Documents are based on NEC ampacity tables using the 75-degree C ratings.

2.03 PROTECTIVE MATTING

- A. Provide full-width, high-voltage switchboard matting in front of indoor switchgear, service equipment, panelboards, and motor control centers.
- B. Provide matting that is 1/4 inch thick and not less than 36 inches deep for the entire length of the equipment, but not less than 36 inches long.
- C. Matting Manufacturer, or Equal
 - 1. W.H.Salisbury and Company
 - 2. Mats, Inc.
 - 3. Rhino

PART 3 -- EXECUTION

3.01 GENERAL

A. Field Control of Location and Arrangement

1. The Drawings diagrammatically indicate the desired location and arrangement of outlets, conduit runs, equipment, and other items.
2. Exact locations shall be determined by the Contractor in the field, based on the physical size and arrangement of equipment, finished elevations, and other obstructions. Follow the locations on the Drawings, however, as closely as possible.
3. Circuits
 - a. Wherever conduits and wiring for lighting and receptacles are not indicated, it shall be the Contractor's responsibility to provide lighting and receptacle-related conduits and wiring as required, based on the actual installed fixture layout and the circuit designations as indicated.
 - b. Provide No. 12 AWG minimum wiring, and 3/4-inch minimum conduits (exposed) and one-inch minimum conduits (encased).
 - c. Where circuits are combined in the same raceway, derate conductor ampacities in accordance with NEC requirements.
4. Workmanship
 - a. Install materials and equipment in strict accordance with the printed recommendations of the manufacturer and using workers skilled in the Work.
 - b. Coordinate installation in the field with other trades to avoid interferences.
5. Protection of Equipment and Materials
 - a. Fully protect materials and equipment against damage from any cause.
 - b. Cover materials and equipment, both in storage and during construction, in such a manner that no finished surfaces will be damaged, marred, or splattered with water, foam, plaster, or paint.
 - c. Keep moving parts clean and dry.
 - d. Replace or refinish damaged materials or equipment, including faceplates of panels and switchboard sections, as part of the work.

3.02 CORE DRILLING

- A. Perform core drilling as required for the installation of raceways through concrete walls and floors.
- B. Base the locations of floor penetrations, as may be required, on field conditions.

- C. Verify exact core drilling locations based on equipment actually furnished as well as exact field placement.
- D. To the extent possible, identify the existence and locations of encased raceways and other piping in existing walls and floors with the Owner prior to any core drilling activities.
- E. Repair damage to encased conduits, wiring, and piping as part of the work.

3.03 CONCRETE HOUSEKEEPING PADS

- A. Provide concrete housekeeping pads for indoor floor-standing electrical equipment.
- B. Extend housekeeping pads for equipment, including future units, 3-1/2 inches above the surrounding finished floor or grade, and 2 inches larger in both dimensions than the equipment, unless otherwise indicated.
- C. Provide concrete housekeeping curbs for conduit stub-ups in indoor locations that are not concealed by equipment enclosures.
- D. Extend housekeeping curbs to 3 inches above the finished floor or grade.

3.04 EQUIPMENT ANCHORING

- A. Floor-supported, wall, or ceiling-hung equipment and raceways shall be anchored in place by methods that will meet seismic requirements in the area where the Project is located. Refer to Section 01 33 17– Structural Design, Support and Anchorage for support and anchorage requirements.
- B. Provide wall-mounted panels that weigh more than 500 pounds or that are within 18 inches of the floor with fabricated steel support pedestals.
- C. If the supported equipment is a panel or cabinet enclosed within removable side plates, match supported equipment in physical appearance and dimensions.
- D. Provide leveling channels anchored to the concrete pad for MCC's, switchgear and other electrical equipment mounted on housekeeping pads.
- E. Manufacturer's Recommendations
 - 1. Anchoring methods and leveling criteria in the printed recommendations of the equipment manufacturers are a part of the work of this Contract.
 - 2. Submit such recommendations as Shop Drawings as indicated.

3.05 SETTING OUT OF WORK

- A. Where equipment is built-in with work of other trades, supply equipment to be built-in or measurements to allow necessary openings to be made so as not to hold up work.

- B. Coordinate between electrical, mechanical, structural, process and architectural drawings when setting out Work. Consult with respective Divisions in setting out locations for conduit runs, luminaires, panel assemblies, etc., so that conflicts are avoided, equipment is operable and serviceable, and symmetrical, even spacing is maintained.
- C. Layouts shown for mechanical and electrical rooms are for general layout purposes only. Coordinate exact installation of conduit, cable trays, outlets and equipment with final room equipment layout using equipment manufacturers' as-built dimensioned drawings.
- D. Where switches and receptacles, are in the same general location, outlets shall be lined up vertically unless otherwise indicated.
- E. Electrical equipment provided as part of prepackaged or prefabricated systems shall be installed in coordination with the vendor requirements and design.

3.06 FINISHES

- A. Clean and touch up surfaces of shop painted equipment scratched or marred during shipment or installation, to match original paint. Obtain touch-up coatings from the original equipment manufacturer to ensure a proper match.

3.07 ARC FLASH LABELLING

- A. Provide arc-flash labels for all distribution equipment, stand-alone disconnects, stand-alone starters, and variable frequency drives. Fill in all values as required by NFPA 70E, and as calculated as part of the Protective Device Study. Install provided arc-flash labels for all equipment where a label has been provided. Verify that all settings as prescribed by the approved Protective Device Study have been implemented in the field.

3.08 CUTTING AND PATCHING

- A. Do not cut or weld to structural members without prior written approval of the Engineer.
- B. Patch all floor, wall or ceilings that are affected by the Work. Patches shall be neatly installed and shall match the surrounding areas.

3.09 CONDUIT AND CABLE INSTALLATION

- A. Install embedded conduit and conduit sleeves prior to placement of concrete. Sleeves through concrete: plastic, sized for free passage of conduit, and protruding 2 inches, unless noted otherwise.
- B. Cables, other than bare copper grounding cable, shall not be directly buried or embedded in concrete.
- C. Ensure all penetrations are properly sealed to prevent ingress of moisture. Above-grade conduit entries subject to flooding (up to the 100 year flood elevation) and below grade conduit entries shall utilize link seals. Conduit entries above the 100 year flood elevation shall be sealed using silicone caulk.

- D. Raceways, fittings and appurtenances that are encased in concrete or direct buried shall be listed for the application.
- E. Firestop all penetrations between fire-rated walls in accordance with Section 07 84 00 – Firestopping.

3.10 LOCATION OF OUTLETS

- A. Locate outlets in accordance with the drawings.
- B. Do not install outlets back-to-back in wall; allow minimum 6 in. horizontal clearance between boxes.
- C. Change location of outlets at no extra cost or credit, providing distance does not exceed 10 ft., and information is given before installation.
- D. Locate light switches on latch side of doors.

3.11 MOUNTING HEIGHTS

- A. Unless required by the Americans with Disabilities Act (ADA) or otherwise noted on the drawings or in the specifications, install electrical devices with their centerlines located above finished floor as follows:

Light Switches	42 in
Disconnect Switches	60 in
Receptacles – Office areas	18 in
Receptacles – Shop/Process areas	24 in
Telephone/Computer Outlets – Office Areas	18 in.
Telephone/Computer Outlets – Other Areas	48 in
Thermostats	60 in
Fire Alarm Pull Station	48 in
Fire Alarm Bell	12 in below finished ceiling
H2S Sensor	12 in

- B. The Engineer reserves the right to change location of any electrical device to within ten (10) feet of point indicated on plans without extra charge provided the Contractor is advised as part of or prior to the rough-in inspection.

3.12 CONSTRUCTION SEQUENCING

A. General

1. Continuous operations of existing facilities during construction is critical. The Contractor shall carefully examine the Work to be provided in, on, or adjacent to existing equipment.
2. Schedule the Work, subject to Owner's approval, to minimize any required shutdown time. The Owner reserves the right to limit or deny shutdowns that restrict the facility's ability to operate within its permit, particularly during unfavorable weather conditions.
3. Submit a written sequencing request, including the sequence and duration of activities to be performed during a partial or complete facility shutdown.

ELECTRICAL GENERAL REQUIREMENTS

4. Switching, safety tagging, and the like, as required for plant shutdown or to isolate existing equipment, shall be performed by the Contractor in the Owner's presence
5. In no case shall the Contractor begin any work in, on, or adjacent to existing equipment without written authorization from the Owner.

B. Modifications

1. Perform modifications or alterations to existing electrical facilities as required to successfully install and integrate the proposed electrical equipment as indicated.
2. Perform modifications to existing equipment, panels, and cabinets in a professional manner. Modifications shall be made in a manner to preserve UL/NRTL listings.
3. Repair coatings to match existing.
4. The costs for modifications to existing electrical facilities that are required for a complete and operating system shall be included as part of the Work.

C. Existing Utilities

1. Exercise extreme caution when digging trenches to not damage existing underground utilities. Perform potholing or other non-destructive method to identify existing utilities prior to performing the required excavations.
2. The cost of repairs of damages caused during construction shall be included as a part of the Work.

D. Installation of Temporary Equipment

1. To facilitate the continuous operation of existing equipment, provide the temporary equipment as required and/or indicated.
2. Submit installation and connection details for review and acceptance by the Engineer.
3. Costs associated with the installation, operation and removal of these temporary installations shall be included as part of the work.
4. Temporary wiring and equipment shall remain the property of the Contractor unless indicated otherwise.

3.13 FIELD QUALITY CONTROL

- A. The Contractor shall provide equipment testing and quality control. Equipment testing shall be in accordance with Section 26 01 26– Electrical Tests and as elsewhere specified in Division 26.
1. Conduct test in presence of Engineer or Owner and, if required, inspectors of the AHJ.
 2. Arrange date(s) of test(s) in advance with Engineer and Owner, testing company and AHJ. Give all inspectors a minimum of 7 days' notice.

3. Contractor shall furnish or arrange for the use of electrical energy or fuel required for all required test(s).
 - B. Repair or replace equipment and systems found inoperative or defective, and re-test.
 1. If test results are not within prescribed limits, document all failed tests and provide recommendations for corrective action to the Owner/Engineer for approval. Provide corrective action and re-test until satisfactory results are obtained.
 2. Continue remedial measures and re-tests until satisfactory results are obtained.
- 3.14 COORDINATION OF PROTECTIVE DEVICES
- A. Ensure that adjustable circuit protective devices such as overcurrent trips, solid state starters, variable frequency drives, motor circuit protector circuit breakers and motor overloads are adjusted to required values and settings.
- 3.15 ADJUST AND CLEAN
- A. Maintain cleanliness during construction by keeping doors closed or openings covered. Provide periodic cleaning of equipment that becomes dusty or dirty during construction.
 - B. Before final acceptance, thoroughly clean the electrical work of cement, plaster, splatters, dirt and other materials.
 - C. Install/clean rubber mats in front of electrical equipment
 - D. Clean washable filters and replace disposable filters on equipment at time of acceptance.
 - E. Remove temporary tags, markings, stickers, and the like.
 - F. Remove oil and grease spots with a non-flammable cleaning solvent by carefully wiping and scraping cracks and corners.
 - G. Apply matching touch-up paint to scratches on panels and cabinets.
 - H. Place equipment drawings in control panel pockets and secure all panel door fasteners.
 - I. Vacuum clean electrical cabinets and enclosures. Do not use compressed air to clean cabinets or rooms.
 - J. Adjust emergency lighting to properly illuminate egress paths. Clean luminaires inside and out. Replace failed lamps or fixtures.
 - K. Properly dispose of cleaning debris and refuse off-site.

3.16 OTHER DIVISIONS

- A. Coordinate the Work with other Divisions. Include labor and materials required to provide a complete, coordinated installation. Typical incidental items shall be provided and include but are not limited to: terminal lugs not furnished with vendor-supplied equipment, compression connectors for cables, splices, junction and terminal boxes, and control wiring required by vendor-supplied equipment to connect with other equipment.

3.17 OTHER CONTRACTORS

- A. Coordinate the work with other Contractors on site to provide a complete installation while minimizing interference with, and disruption to, other projects.

END OF SECTION

SECTION 26 01 26 – ELECTRICAL TESTS

PART 1 -- GENERAL

1.1 THE SUMMARY

- A. This Section specifies the WORK necessary to test, commission, and demonstrate that the electrical work satisfies the criteria of these Specifications and functions as required by the Contract Documents.
- B. The WORK of this Section includes furnishing the labor, equipment, and power required to support the testing indicated in other Divisions of these Specifications. Electrical testing indicated herein and functional testing of power and controls not tested under Division 40 - Instrumentation, shall be completed. This scope may require the CONTRACTOR to activate circuits, shutdown circuits, run equipment, make electrical measurements, replace blown fuses, and install temporary jumpers, etc.
- C. The requirements of Section 26 00 10 - Electrical General Requirements, apply to the WORK of this Section.
- D. Carry out tests indicated herein for individual items of materials and equipment in other Sections. Testing shall be done in accordance with the manufacturer's instructions, these Specifications, and applicable NETA Acceptance Testing Specifications, NEMA, ANSI, NFPA, and ASTM Standards.

1.2 REFERENCES

- A. General
 - 1. The publications listed below form a part of this specification to the extent referenced.
 - 2. Where a date is given for reference standards, the edition of that date shall be used. Where no date is given for reference standards, the latest edition available on the date of the Notice Inviting Bids shall be used.
- B. American National Standards Institute (ANSI)
- C. Institute of Electrical and Electronics Engineers, Inc. (IEEE)
- D. IEEE 400-2001, Guide for Field Testing and Evaluation of the Insulation of Shielded Power Cable Systems
- E. IEEE 576-2000, Recommended Practice for Installation, Termination, and Testing of Insulated Power Cable as Used in Industrial and Commercial Applications
- F. International Electrical Testing Association (NETA)
- G. NFPA 70, National Electrical Code (NEC)

1.3 SUBMITTALS

- A. Submit in accordance with Section 01 33 00, Submittal Procedures.

- B. Submit complete system test procedures for review. Test procedures shall include but not be limited to:
 - 1. Detailed procedures in sufficient detail to verify conformance with these Specifications.
 - 2. Incorporation of the Test Record Sheets included at the end of this Section.
 - 3. Detailed comprehensive testing schedule including:
 - a. Each major piece of electrical distribution equipment.
 - b. Each major electrical subsystem.
 - c. Duration of each test.
 - d. Milestone test completion date.
 - e. Ambient Conditions at time of test
 - f. Date of test results submittals following completion of the tests.
 - g. Names and qualifications of the individual(s) responsible for performing the testing.
 - C. Following completion of the test submit the completed test results to the Engineer for review. The results shall include a dedicated section with the “as-left” settings of all devices, relays, circuit breakers, etc.
 - D. Test result shall be submitted in one submittal.
 - E. Test reports shall be based on NETA's latest Acceptance Testing Specifications having a sign-off, pass/fail data filed for each line item covered by NETA's Acceptance Testing Specifications latest edition.
- 1.4 COMMISSIONING
- A. Commissioning during the 7 Day test in Section 01 75 00 shall not be attempted until all subsystems have been found to operate satisfactorily. Commissioning shall only be attempted as a function of normal plant operation in which plant process flows and levels are routine, and equipment operates automatically in response to flow and level parameters or computer command, as applicable. Simulation of process parameters shall be considered only upon receipt of a written request by the CONTRACTOR.
 - B. Motor Current Tabulation
 - 1. The motor current tabulation required by Section 26 05 73 – Protective Device Studies shall reflect the values occurring during commissioning.

PART 2 -- TESTING & REPORTS

2.1 PRE-ENERGIZATION AND OPERATING TESTS

- A. The complete electrical system shall be performance tested when first installed on-site. Each protective, switching, and control circuit shall be adjusted in accordance with the recommendations of the protective device study and tested by actual operation using current injection or equivalent methods as necessary to ensure that each and every such circuit operates correctly to the satisfaction of the authority having jurisdiction.
 - 1. Instrument Transformers. All instrument transformers shall be tested to verify correct polarity and burden.
 - 2. Protective Relays. Each protective relay shall be demonstrated to operate by injecting current or voltage, or both, at the associated instrument transformer output terminal and observing that the associated switching and signaling functions occur correctly and in proper time and sequence to accomplish the protective function intended.
 - 3. Switching Circuits. Each switching circuit shall be observed to operate the associated equipment being switched.
 - 4. Control and Signal Circuits. Each control or signal circuit shall be observed to perform its proper control function or produce a correct signal output.
 - 5. Metering Circuits. All metering circuits shall be verified to operate correctly from voltage and current sources, similarly to protective relay circuits.
 - 6. Acceptance Tests. Complete acceptance tests shall be performed, after the station installation is completed, on all assemblies, equipment, conductors, and control and protective systems, as applicable, to verify the integrity of all the systems.
 - 7. Relays and Metering Utilizing Phase Differences. All relays and metering that use phase differences for operation shall be verified by measuring phase angles at the relay under actual load conditions after operation commences.
- B. Test Report. A test report covering the results of the tests required in the Pre-Energization and Operating Tests shall be delivered to the authority having jurisdiction prior to energization. Acceptance Testing shall be in accordance with NETA ATS-2017, *For Electrical Power Equipment and Systems*, published by the International Electrical Testing Association.

2.2 TEST REQUIREMENTS

- A. The following test requirements supplement test and acceptance criteria that may be stated elsewhere.
 - 1. Lighting: Switching, include remote control, if present in system. Circuitry is in accordance with panel schedules. All interior and exterior lighting shall be checked for proper operation.
 - 2. Power Instrumentation: Demonstrate that voltmeter and ammeter switches are functional. Demonstrate that kilowatt meters are within catalog accuracy as installed.

- a. Visual and Mechanical Inspection
 - 1) Compare equipment nameplate data with drawings and specifications.
 - 2) Inspect physical and mechanical condition.
 - 3) Verify tightness of electrical connections.
 - 4) Inspect cover gasket, cover glass, condition of spiral spring, disk clearance, contacts, and case-shorting contacts, as applicable.
 - 5) Verify freedom of movement, end play, and alignment of rotating disk(s).
- b. Electrical Tests
 - 1) Verify accuracy of meters at all cardinal points.
 - 2) Calibrate watt-hour meters according to manufacturer's published data.
 - 3) Verify all instrument multipliers.
 - 4) Verify that current transformer and voltage transformer secondary circuits are intact.
- 3. Demonstrate mechanical and/or electrical interlocking by attempting to subvert the intended sequence.
- 4. Activate ground fault tripping by operating test features provided with ground current protective systems and by injecting a known and reasonable current in the ground current sensor circuit. In general, ground fault tripping should occur at a ground current equivalent to 20 percent of phase current. Current injection is not required of circuit 400 amperes or less.
- 5. Low Voltage Cables-600 volts Maximum
 - a. Visual and Mechanical Inspection
 - 1) Compare cable data with drawings and specifications.
 - 2) Inspect exposed sections of cables for physical damage and correct connection in accordance with single-line diagram.
 - 3) Inspect bolted electrical connections for high resistance using one of the following methods:
 - a) Use of low-resistance ohmmeter
 - b) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data or NETA ATS- 2017, Table 100.12.
 - c) Perform thermographic survey in accordance with below Section Thermographic Survey.

- 4) Inspect compression-applied connectors for correct cable match and indentation.
 - 5) Inspect for correct identification and arrangements.
 - 6) Inspect cable jacket insulation and condition.
- b. Electrical Tests
- 1) Perform insulation-resistance test on each conductor with respect to ground and adjacent conductors. Applied potential shall be 500 volts dc for 300 volt rated cable and 1000 volts dc for 600 volt rated cable. Test duration shall be one minute.
 - a) Motor feeders tested with motors disconnected and controller open.
 - b) Motor control circuits tested and verified for proper operation with control stations and overcurrent devices connected.
 - c) Panelboard feeders tested with feeder breaker open and panelboard connected. If a lighting transformer is associated with the panelboard, it shall be connected, and the test made for both primary and secondary sides.
 - d) Conductors of main lighting feeders, including lighting panel with branch circuits open.
 - e) Prior to performing insulation resistance tests on cables, verify that they are not connected to a solid-state device.
 - f) Equipment which may be damaged during this test shall be disconnected.
 - g) The Engineer shall be consulted if minimum insulation values cannot be obtained.
 - 2) Perform resistance measurements through all bolted connections with low-resistance ohmmeter, if applicable.
 - 3) Perform continuity test to insure correct cable connection.
- c. Test Values – Visual and Mechanical
- 1) Compare bolted connection resistance to values of similar connections. Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
 - 2) Bolt-torque levels should be in accordance with NETA ATS-2017, Table 100.12 unless otherwise specified by the manufacturer.
 - 3) Results of the thermographic survey shall be in accordance with the below Section Thermographic Survey.
- d. Test Values – Electrical

- 1) Compare bolted connection resistance values to values of similar connections. Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
 - 2) Insulation-resistance values shall be in accordance with manufacturer's published data. In the absence of manufacturer's published data, use NETA ATS-2017 Table 100.1. Values of insulation resistance less than this table or manufacturer's recommendations shall be investigated.
 - 3) Cable shall exhibit continuity.
 - 4) Deviations in resistance between parallel conductors shall be investigated.
6. Test ground interrupter (GFI) receptacles and circuit breakers for proper operation by methods sanctioned by the receptacle manufacturer.
7. A functional test and check of electrical components is required prior to performing subsystem testing and commissioning. Compartments and equipment shall be cleaned as required by other provisions of these Specifications before commencement of functional testing. Functional testing shall comprise:
 - a. Visual and physical check of cables, circuit breakers, transformers, and connections associated with each item of new and modified equipment.
 - b. Verification that electrical equipment has been labeled with Arc Flash protection boundary and PPE levels, as required by Section 26 05 73 – Protective Device Studies.
 - c. Setting of protective relays in conformance with results of the Short Circuit Study required by Section 26 05 73 - Protective Device Studies and testing of relays to assure that relays will trip at the current value and time required by the Study.
 - d. Circuit Breakers
 - 1) Circuit breakers that have adjustable time or pick-up settings for ground current, instantaneous overcurrent, short-time overcurrent, or long-time overcurrent, shall be field-adjusted by a representative of the circuit breaker manufacturer.
 - 2) Time and pickup setting shall correspond to the recommendations of the Short Circuit Study.
 - 3) Setting shall be tabulated and proven for each circuit breaker in its installed position.
 - 4) Test results shall be certified by the person performing the tests and shall be submitted to the ENGINEER.
8. Complete ground testing of grounding electrodes per requirements below prior to operating the equipment.

- B. Subsystem testing shall occur after the proper operation of alarm and status contacts has been demonstrated or otherwise accepted by the ENGINEER and after process control devices have been adjusted as accurately as possible. Alarm conditions shall be simulated for each alarm point, and alarm indicators shall be checked for proper operation. It is intended that the CONTRACTOR will adjust limit switches and level switches to their operating points prior to testing and will set pressure switches, flow switches, and timing relays as dictated by operating results.
- C. Metering and indication lights for motors and other devices shall be tested for proper operation.
- D. All control circuits such as motor, interlock and remote shall be tested for proper operation.
- E. After initial settings have been completed, each subsystem shall be operated in the manual mode, and it shall be demonstrated that operation is in compliance with the Contract Documents. Once the manual mode of operation has been proven, automatic operation shall be demonstrated to verify such items as proper start and stop sequence of pumps, proper operation of valves, proper speed control, etc.
- F. Motor operated valves shall be tested after having been phased and tested for correct motor rotation and after travel and torque limit switches have been adjusted by a representative of the valve manufacturer. Tests shall verify status indication, proper valve travel, and correct command control from local and remote devices.
- G. All lighting panels, circuits and fixtures; and power panels, circuits and receptacles shall be tested for proper operation.
- H. Provide ground resistance tests on the main grounding electrode or system in the presence of the ENGINEER and submit results.
 - 1. Visual and Mechanical Inspection
 - a. Verify ground system follows drawings and specifications.
 - 2. Electrical Tests
 - a. Perform fall-of-potential test or alternative in accordance with IEEE Standard 81 on the main grounding electrode or system.
 - b. The earth resistance of each ground electrode shall be measured and recorded before electrodes are connected to the grounding loop.
 - c. Perform point-to-point tests to determine the resistance between the main grounding system and all major electrical equipment frames, system neutral, and/or derived neutral points.
 - 3. Test Values
 - a. The resistance between the main grounding electrode and ground shall be no greater than five ohms for commercial or industrial systems and one ohm or less for generating or transmission station grounds unless otherwise specified by the owner.

- b. Investigate point-to-point resistance values which exceed 0.5 ohm.
- I. Subsystems shall be defined as individual and groups of pumps, conveyor systems, chemical feeders, air conditioning units, ventilation fans, air compressors, etc.
- J. THERMOGRAPHIC SURVEY
 - 1. Visual and Mechanical Inspection
 - a. Inspect physical, electrical, and mechanical condition.
 - b. Remove all necessary covers prior to thermographic inspection. Utilize appropriate caution, safety devices, and personal protective equipment.
 - 2. Equipment to be inspected shall include all 120 volt and higher current-carrying devices including all switchgear, switchboards, distribution panels, cable and bus connections, motor control centers and starters, disconnect switches, and other critical equipment. Testing of lighting luminaires, field instrumentation, SCADA & PLC's are not required.
 - 3. Provide report including the following:
 - a. Description of equipment to be tested.
 - b. Discrepancies.
 - c. Temperature difference between the area of concern and the reference area.
 - d. Probable cause of temperature difference.
 - e. Areas inspected. Identify inaccessible and/or unobservable areas and/or equipment.
 - f. Identify load conditions at time of inspection.
 - g. Provide photographs and/or thermograms of the deficient area.
 - h. Recommended action.
 - 4. Test Parameters
 - a. Inspect distribution systems with imaging equipment capable of detecting a minimum temperature difference of 1°C at 30°C.
 - b. Equipment shall detect emitted radiation and convert detected radiation to visual signal.
 - c. Thermographic surveys should be performed during periods of maximum possible loading but not less than 40 percent of rated load of the electrical equipment being inspected. Refer to ANSI/NFPA 70B-2010, Section 11-17 (Infrared Inspection).
 - 5. Test Values
 - a. Suggested actions based on temperature rise can be found in Table 100.18.

6. RE-INSPECTION

- a. All items that are reported deficient in the thermography reports section of the inspection report shall be re-inspected after repairs have been made.
- b. Original specification will apply to re-inspections.
- c. Submit re-inspection reports and indicate that repairs have fixed the anomaly or indicate any remaining anomalies.
- d. Perform a follow-up thermographic survey within 12 months of final acceptance by the owner.

2.3 TEST REPORTS

- A. The test report shall include the following:
 1. Summary of project.
 2. Description of equipment tested.
 3. Description of test.
 4. Test data.
 5. Analysis and recommendations.
- B. Test data records shall include the following minimum requirements:
 1. Identification of the testing organization.
 2. Equipment identification.
 3. Humidity, temperature, and other atmospheric conditions that may affect the results of the tests/calibrations.
 4. Date of inspections, tests, maintenance, and/or calibrations.
 5. Identification of the testing technician.
 6. Indication of inspections, tests, maintenance, and/or calibrations to be performed and recorded.
 7. Indication of expected results when calibrations are to be performed.
 8. Indication of "as-found" and "as-left" results.
 9. Sufficient spaces to allow all results and comments to be indicated.
- C. The testing firm shall furnish a copy or copies of the complete report to the owner as required in the acceptance contract.

TABLE 100.18

**THERMOGRAPHIC SURVEY
SUGGESTED ACTIONS BASED ON TEMPERATURE RISE**

Temperature difference (ΔT) based on comparisons between similar components under similar loading.	Temperature difference (ΔT) based upon comparisons between component and ambient air temperatures.	Recommended Action
1°C - 3°C	1°C - 10°C	Possible deficiency; warrants investigation
4°C - 15°C	11°C - 20°C	Indicates probable deficiency; repair as time permits
- - - - -	21°C - 40°C	Monitor until corrective measures can be accomplished
>15°C	>40°C	Major discrepancy; repair immediately

Temperature specifications vary depending on the exact type of equipment. Even in the same class of equipment (i.e., cables) there are various temperature ratings. Heating is generally related to the square of the current; therefore, the load current will have a major impact on ΔT . In the absence of consensus standards for ΔT , the values in this table will provide reasonable guidelines.

An alternative method of evaluation is the standards-based temperature rating system as discussed in Chapter 8.9.2, Conducting an IR Thermographic Inspection, *Electrical Power Systems Maintenance and Testing*, by Paul Gill, PE, 1998.

It is a necessary and valid requirement that the person performing the electrical inspection be thoroughly trained and experienced concerning the apparatus and systems being evaluated as well as knowledgeable of thermographic methodology.

END OF SECTION

SECTION 26 05 10 - ELECTRIC MOTORS

PART 1 -- GENERAL

1.1 THE SUMMARY

- A. General: The CONTRACTOR shall provide electric motors, accessories, and appurtenances complete and operable, in conformance to the Contract Documents.
- B. The provisions of this Section apply to low voltage 3 phase, AC squirrel cage induction motors throughout the Contract Documents, except as indicated otherwise.
- C. The CONTRACTOR shall assign to the equipment supplier the responsibility to select suitable electric motors for the equipment. The choice of motor manufacturer shall be subject to review by the ENGINEER. Such review will consider future availability of replacement parts and compatibility with driven equipment.

1.2 CONTRACTOR SUBMITTAL

- A. Furnish submittals in accordance with Section 01 33 00 - Submittal Procedures.
- B. Complete motor data shall be submitted with the driven machinery Shop Drawings. Motor data shall include:
 - 1. Machine name and specification number of driven machine
 - 2. Motor manufacturer
 - 3. Motor type or model and dimension drawing. Include motor weight.
 - 4. Nominal horsepower
 - 5. NEMA design
 - 6. Enclosure
 - 7. Frame size
 - 8. Winding insulation class and temperature rise class.
 - 9. Voltage, phase, and frequency ratings
 - 10. Service factor
 - 11. Full load current at rated horsepower for application voltage
 - 12. Full load speed
 - 13. Guaranteed minimum full load efficiency. Also, nominal efficiencies at 1/2 and 3/4 load.
 - 14. Type of thermal protection or overtemperature protection, where included.

15. Wiring diagram for devices such as motor leak detection, temperature, or zero speed switches, as applicable
 16. Bearing data. Include recommendation for lubricants of relubricate type bearings.
 17. If utilized with a variable frequency controller, verify motor is inverter duty type. Include minimum speed at which motor may be operated for the driven machinery. Provide shaft grounding details and information. Provide insulated bearing details and information.
 18. Power factor at 1/2, 3/4 and full load.
 19. Recommended size for power factor correction capacitors to improve power factor to 0.95 percent lagging when operated at full load.
- C. If water cooling is required for motor thrust bearings, the Shop Drawing submittals shall indicate this requirement.

PART 2 -- PRODUCTS

2.1 GENERAL REQUIREMENTS

- A. Electric motors driving identical machines shall be identical.
- B. Maximum motor loading shall be equal to nameplate horsepower rating or less, exclusive of service factor and be verifiable from the submittal data of the driven machinery.
- C. Motor Capacity
 1. The CONTRACTOR shall size motors for the larger of the following criteria:
 - a. Size motors to continuously carry the maximum load that develops across the full range of driven equipment operation.
 - b. Size motors for minimum size indicated.
 2. In every case, motor size shall be derated from nameplate values as follows:
 - a. Ambient Temperature
 - 1) For ambient temperatures up to but not exceeding 40 degrees C, no derating is required.
 - 2) For ambient temperatures exceeding 40 degrees but less than 50 degrees C, derate nameplate HP ratings to 85 percent.
 - b. Site Altitude: No derating is required for altitudes less than 3300 feet (1000 meters).
 3. Increased circuit breaker, magnetic starter, and conductor and conduit capacities required for motors larger than the indicated sizes shall be provided as part of the WORK.

- D. Exempt Motors: Motors for valve operators, submersible pumps, or motors which are an integral part of standard manufactured equipment, i.e., non-NEMA mounting, common shaft with driven element, or part of domestic or commercial use apparatus may be excepted from these requirements to the extent that such variation reflects a necessary condition of motor service or a requirement of the driven equipment.

2.2 DESIGN REQUIREMENTS

- A. General: Electric motors shall comply with NEMA MG-1 - Motor and Generator. Motors used with adjustable frequency drives shall comply with NEMA MG-1, Part 31, and shall be clearly identified as "Inverter Duty."
- B. NEMA Design: Electric motors shall be NEMA Design B unless otherwise indicated. In no case shall starting torque or breakdown torque be less than the value in NEMA MG 1. Motors shall be suitable for the indicated starting method.
- C. Motor Voltage Ratings: Low voltage motors shall have voltage ratings in accordance with the following, unless otherwise indicated:
 - 1. Motors below 1/2 HP shall be rated 115 volts, single phase, 60 Hz. Dual voltage motors rated 115/230 volts, 115/208 volts, or 120-240 volts are acceptable, provided leads are brought out to the conduit box.
 - 2. Motors 1/2 HP and larger shall be rated, 460 volts, 3 phase, 60 Hz. Dual voltage motors rated 230/460 volts or 208/230/460 volts are acceptable, provided every lead is brought out to the conduit box.
- D. Insulation: Three phase motors shall be provided with Class F insulation, rated to operate at a maximum ambient temperature of 40 degrees C and at the altitudes where the motors will be installed and operated, without exceeding Class B temperature rise limits stated in NEMA MG 1-12.44. Single phase motors shall have Class F insulation with temperature rise not to exceed the insulation class. Motors to be operated from adjustable frequency drives shall be provided with insulation systems to withstand 1600 volt spikes, with dV/dT as defined in NEMA MG 1-31. The adjustable frequency drive manufacturer shall coordinate with the motor manufacturer to determine when additional dV/dT protection is required. Where required, it shall be furnished and installed as per the manufacturer's written instructions.
- E. Motors 50 HP or smaller located in non-hazardous areas shall be totally enclosed, fan cooled (TEFC) with a Service Factor of 1.15 for non-VFD applications and service factor of 1.15 (sine)/1.0 (inverter) for VFD applications.
- F. Motors 50 HP and greater located in non-hazardous areas shall be TEFC with a service factor of 1.15 for non-VFD applications and service factor of 1.15 (sine)/1.0 (inverter) for VFD applications.
- G. Motors larger than 50 HP installed outdoors or in unheated areas or indicated shall be provided with 120 volt AC space heaters, wired to a terminal strip in a low voltage motor junction box. If provided by the manufacturer when not specified, the manufacturer shall not require that they be connected or the CONTRACTOR shall connect them at no extra cost to the OWNER, in order to keep the warranty in force.
- H. NEMA Premium Efficiency Motors

1. Motors with a nameplate rating of 1 HP and larger shall be NEMA premium efficient units. Motors shall be stamped with the efficiency on the nameplate with the caption "NEMA Nominal Efficiency" or "NEMA Nom. Eff." Such motors shall have efficiencies determined by the test as set forth in ANSI/IEEE 112 - Standard Test Procedure for Polyphase Induction Motors and Generators, Method B.
2. Efficiency: Nominal efficiency and minimum efficiency shall be defined in accordance with NEMA efficiency tables. Efficiencies shall be included in the Shop Drawing submittal.
3. Two speed motors shall be of the 2 winding type.

I. ACCESSORY REQUIREMENTS

- J. General: Horizontal motors 3 HP and larger and every vertical motor shall have split-type cast metal conduit boxes. Motors shall be provided with oversized conduit boxes. Where conduit sizes indicated do not match the motor terminal box, the CONTRACTOR shall provide means to accommodate the motor requirements. Motor boxes other than open drip-proof shall be gasketed.
- K. Lifting Devices: Motors weighing 265 lb (120 Kg) or more shall have suitable lifting eyes for installation and removal.
- L. Special Requirements: The CONTRACTOR shall refer to individual equipment specifications for special requirements such as motor winding thermal protection or multi-speed windings.
- M. Grounding Lugs: Provide motor grounding lug suitable to terminate ground wire, sized as indicated.
- N. Nameplate: Motors shall be fitted with permanent stainless steel nameplates indelibly stamped or engraved with NEMA Standard motor data, in conformance with NEMA MG-1-10.40. Inverter duty motors shall be clearly identified as such.
- O. Where motors are indicated by elementary schematics or specifications to have zero speed switches, the switches shall be factory mounted integral to the motors. Switches shall close the contacts when the motor is at zero speed.
- P. Inverter duty motors shall be provided with shaft grounding rings. Rings shall be factory installed, and shall be manufactured by **Aegis**, or equal. The motor warranty shall include coverage against VFD-induced bearing damage or failure.
- Q. The motor manufacturer shall furnish for installation by the CONTRACTOR power factor correction capacitors for each motor 10HP and larger, and started with FVNR, FVR, FVNR-AT (auto-transformer) or FVTS (two-speed, high speed winding corrected) starters only. Motors started with VFDs shall not have capacitors. Reduced voltage, solid state starters shall be provided with capacitors, where specifically shown. The capacitors shall be fused, with internal resistors, suitably enclosed for mounting adjacent to the starter, MCC, or the motor, and sized to improve power factor to not less than 95% at full load. Size shall be as recommended by the motor manufacturer. The capacitors shall be wired to the motor starter output terminals. Dielectric fluid shall be non-PCB, biodegradable and non-flammable.

2.3 MOTOR THERMAL PROTECTION

- A. Single Phase Motors: Single phase 120, 208, or 230 volt motors shall have integral thermal overload protection or shall be inherently current limited.
- B. Thermostats: Where indicated or specified, winding thermostats shall be snap action, bi-metallic, temperature-actuated switch. Thermostats shall be provided with one normally closed contact. The thermostat switch point shall be pre-calibrated by the manufacturer. All inverter duty motors shall be provided with winding thermostats, unless RTDs are specified. All explosion-proof motors shall be provided with winding thermostats.
- C. RTDs: Bearing RTDs and/or winding RTDs (2 per phase) shall be provided where indicated. RTDs shall be 100 ohm platinum. CONTRACTOR shall provide a trip relay for each high temperature alarm signal.

2.4 MOTOR BEARINGS

- A. General: Bearings shall conform to Section 46 01 00 - Equipment General Provisions, except as indicated herein.
- B. Motors greater than 2 HP shall have bearings designed for 17,500 hours (belted) or 100,000 hours (coupled) L-10 life.
- C. Fractional Horsepower: Motors with fractional horsepower through 2 HP shall be provided with lubricated-for-life ball bearings.
- D. Horizontal Motors Over 2 HP: Motors larger than 2 HP shall be provided with relubricatable ball bearings. Lubrication shall be per manufacturer's recommendation for smooth operation and long life of the bearings.
- E. Vertical Motors Over 2 HP: Vertical motors larger than 2 HP shall be provided with relubricatable ball, spherical, roller, or plate type thrust bearings. Lubrication shall be per manufacturer's recommendation for smooth operation and long life of the bearings.
- F. Water Cooled Motors: If water cooling is required for the thrust bearings, cooling water lines shall be provided complete with shut-off valve, strainer, solenoid valve, flow indicator, thermometer, throttling valve, and, (where subject to freezing), insulation with heat tracing.
- G. Inverter Duty Motors: Provide an insulated bearing to prevent circulating bearing currents.

2.5 MANUFACTURERS, OR EQUAL

- A. **U.S. Motors/Nidec**
- B. **Baldor**
- C. **WEG**

PART 3 -- EXECUTION

3.1 INSTALLATION

- A. Motor installation shall be performed in accordance with the motor manufacturer's written recommendations and the written requirements of the manufacturer of the driven equipment. Shaft grounding devices shall be connected to the grounding system in accordance with the manufacturer's recommendations.
- B. Related electrical WORK involving connections, controls, switches, and disconnects shall be performed in accordance with the applicable sections of Division 26.

3.2 FACTORY TESTING

- A. Motors rated 100 HP and larger shall be factory tested in conformance with IEEE 112, IEEE 43 - Recommended Practice for Testing Resistance of Rotating Machinery, and NEMA MG-2. Except where specific testing or witnessed shop tests are required by the specifications for driven equipment, factory test reports may be copies of routine test reports of electrically duplicate motors. Test report shall indicate test procedure and instrumentation used to measure and record data. Test report shall be certified by the motor manufacturer's test personnel and be submitted to the ENGINEER.

3.3 FIELD TESTING

- A. The CONTRACTOR shall perform the following field tests (see also Section 26 01 26 – Electrical Testing):
 - 1. Inspect each motor installation for any deviation from rated voltage, phase, frequency, and improper installation.
 - 2. Visually check for proper phase and ground connections. Verify that multi-voltage motors are connected for proper voltage. Verify shaft grounding devices are properly grounded.
 - 3. Check winding and bearing temperature detectors and space heaters for functional operation. Verify RTD monitors are properly programmed and protection setpoints are correct and enabled.
 - 4. Test for proper rotation prior to connection to the driven equipment.
 - 5. Visually check that motor overload heaters are properly sized and that MCP breaker settings are correct for the motor installed.
 - 6. Test insulation (megger test) of new and re-used motors in accordance with NEMA MG-1. Test voltage shall be 500 VAC.

END OF SECTION

SECTION 26 05 15 – INDUSTRIAL CONTROL PANELS AND MISCELLANEOUS DEVICES

PART 1 -- GENERAL

1.1 THE SUMMARY

- A. The CONTRACTOR shall provide complete industrial control panels and/or local control stations as indicated herein or in other Sections of the Specifications. The stations shall be designed to provide the sequence of operation in Section 40 91 00– Process Control and Instrumentation Systems and the P&ID Drawings
- B. This section also specifies miscellaneous electrical devices used throughout this project. These devices are not limited to use within industrial control panels or local control stations.

1.2 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

- A. Industrial control panels and/or local control stations shall comply with the requirements of NEC (including Article 409), NEMA, and UL.

1.3 SUBMITTAL PROCEDURES

- A. Furnish Shop Drawings in accordance with Sections 01 33 00– Submittal Procedures and 26 00 10– Electrical General Requirements.
 - 1. Ladder diagrams and written descriptions explaining ladder diagram operation and system operation.
 - 2. Include catalog cuts of control equipment including enclosures, overcurrent devices, relays, pilot devices, terminations, and wire troughs.

PART 2 -- PRODUCTS

2.1 GENERAL

- A. The CONTRACTOR shall provide the equipment, panels and stations to satisfy the functional requirements in the relevant mechanical equipment and Instrumentation and Control specifications and the Electrical Elementary Schematics. Each panel and station shall be fabricated with UL labeled components. Equipment not specifically indicated as being WORK of other Sections shall be provided under this Section. All equipment, panels and stations shall be wired under this Section.
- B. The controls shall be 120 V maximum. Where the electrical power supply is 240 V, single phase or 480 V, 3 phase, the station shall be provided with a fused control power transformer. Control conductors shall be provided in accordance with Section 26 05 19 – Wire and Cabling
- C. Each panel and/or station shall be provided with identified terminal strips for the connection of external conductors. The CONTRACTOR shall provide sufficient terminal blocks to connect 25 percent additional conductors for future use. Termination points shall be identified in accordance with Shop Drawings. The panels and/or stations shall be the source of power for all 120 VAC solenoid valves interconnected with the panels

and/or stations. Equipment associated with the panels and/or stations shall be ready for service after connection of conductors to equipment, controls, panels and/or stations.

- D. Wiring to door-mounted devices shall be extra flexible and anchored to doors using wire anchors cemented in place. Exposed terminals of door-mounted devices shall be guarded to prevent accidental personnel contact with energized terminals.
- E. Enclosures
 - 1. In finished rooms, enclosures shall be NEMA 1 steel enclosures painted with ANSI 61 exterior and white interior.
 - 2. In all other non-hazardous areas, enclosures shall be NEMA 4X stainless steel with brushed finish. Where possible, penetrations shall be made in such a manner to maintain the NEMA 4X rating. If this is not possible, the penetrations shall be made in such a manner to minimize entry of foreign materials into the enclosure, subject to approval by the ENGINEER.
 - 3. Enclosures shall be freestanding, pedestal-mounted, or equipment skid-mounted, as indicated. Internal control components shall be mounted on a removable mounting pan. Mounting pan shall be finished white.
 - 4. Outdoor mounted enclosures shall be provided with thermostatically-controlled heaters. Heaters shall be operated at ½ rated voltage (240 volt heaters shall be sized and operated at 120 volts).
 - 5. Provide screened weep holes for draining condensation
- F. Disconnect Switches
 - 1. Heavy duty, fusible, single throw switches shall be rated not less than 65 KA at 480 VAC.
 - 2. Horsepower rated
 - 3. UL listed
 - 4. Padlockable in "Off" position and door interlock
 - 5. Enclosure per area classification in Section 26 00 10 – Electrical General Requirements.
 - 6. 480 V, 3-phase, 3-pole (6-pole when used with 2-speed motor).
 - 7. Auxiliary control contact where indicated.
 - 8. As manufactured by **G.E., Eaton Electrical, Square D**, or equal.
- G. Identification of panel-mounted devices, conductors, and electrical components shall be in accordance with Section 26 00 10 – Electrical General Requirements.
- H. Panel-mounted devices shall be mounted a minimum of 3-feet above finished floor elevation, but not higher than 6'-6" above finished floor, unless noted otherwise.

2.2 PANEL/STATION COMPONENTS

- A. Pushbuttons, selector switches, and pilot lights shall be the heavy-duty, oil-tight type, sized to 30-mm. Miniature style devices are not acceptable. Devices shall be as manufactured by **General Electric, Eaton Electrical, Square D**, or equal.
 - 1. Lens colors shall be:
 - a. red for "run," "open," or "on";
 - b. green for "stopped," "closed," or "off"; and
 - c. amber for alarm.
 - 2. Pilot lights shall be full voltage, push-to-test, LED cluster type.
- B. Relays shall be 3 PDT with 10 amp contacts, plug-in type with indicating light, rectangular blades and provided with sockets for screw-type termination and hold-down clips. Relays shall be as manufactured by **Square D, Potter Brumfield**, or equal.
- C. Elapsed time meters shall be non-resettable type, read to a maximum of 99999.9 hours and shall be as manufactured by **General Electric, Eaton Electrical**, or equal.
- D. Magnetic starters shall be:
 - 1. NEMA rated, Size 1 minimum. IEC or dual NEMA/IEC rated type are not acceptable.
 - 2. FVNR type unless indicated otherwise.
 - 3. Combination starters with magnetic only instantaneous trip circuit breakers such as **Eaton Electrical HMCP, General Electric Mag-Break**, or equal. Breakers shall be rated 65 KA minimum.
 - 4. Control transformers shall be provided with primary and secondary fuses, 120 V maximum control voltage. VA rating of transformer shall be based on devices on the control schematic.
- E. Terminal strips shall be provided for every panel and shall be the flanged fork or ring lug type suitable for No. 12 AWG stranded wire minimum. Provide 25 percent spare terminals in each panel.
- F. Time delay relays shall be combination on delay and off delay (selectable) with adjustable timing ranges. Provide socket with screw terminal connections and retaining strap. Time delay relays shall be **Square D, ATC, Eaton Electrical**, or equal.

2.3 FACTORY TESTING

- A. Each panel/station shall be factory assembled and tested for sequence of operation prior to delivery.

2.4 SPARE PARTS

- A. Provide a minimum of 10 percent spare lamps (minimum 2) and one spare lens for each color pilot lamp in each panel.

PART 3 -- EXECUTION

3.1 INSTALLATION

- A. Panels/stations shall be installed in accordance with in Section 26 00 10– Electrical General Requirements and in accordance with the manufacturer's recommendations.
- B. Panels/stations shall be protected at the site from loss, damage, and the effects of weather. Panels/stations shall be stored in an indoor, dry location. Heating shall be provided in areas subject to corrosion and humidity.
- C. Panels/station interiors and exteriors shall be cleaned, and coatings shall be touched up to match original finish upon completion of the WORK.
- D. Conduit, conductors, and terminations shall be installed in accordance with Section 26 00 10 – Electrical General Requirements.

3.2 FIELD TESTING

- A. Each panel/station shall be tested again for functional operation in the field after the connection of external conductors and prior to equipment startup.

END OF SECTION

SECTION 26 05 19 - WIRE AND CABLING

PART 1 -- GENERAL

1.1 THE SUMMARY

- A. The CONTRACTOR shall provide wire and cable, complete and operable, in accordance with the Contract Documents.
- B. In the event that motors provided are larger horsepower than the motors indicated, raceways, conductors, starters, overload elements, and branch circuit protectors shall be revised as necessary to control and protect the increased motor horsepower in accordance with Section 26 05 10 – Electric Motors. Revisions are part of the WORK of this Section.

1.2 ACTION SUBMITTALS

- A. The CONTRACTOR shall submit Shop Drawings in accordance with Sections 01 33 00 – Submittal Procedures and 26 00 10 – Electrical General Requirements. Submit cable test results in accordance with this Section as well as Section 26 01 26 – Electrical Tests.

1.3 DELIVERY, STORAGE AND HANDLING

- A. The CONTRACTOR shall protect all cables from damage at all times.
- B. Cable ends shall be protected from water entry in accordance with the manufacturer's recommended procedures. Cable ends shall not be left open in manholes or other locations subject to submergence. If the cable ends become submerged prior to splicing or termination, the cables shall be replaced in their entirety.
- C. Cables shall be pulled into raceways in accordance with the manufacturer's requirements. Under no circumstances shall cable pulling tensions exceed the manufacturer's written instructions.
- D. Pulling tensions on raceway cables shall be within the limits recommended by the cable manufacturer. Wire pulling lubricant, where needed, shall be UL approved.

PART 2 -- PRODUCTS

2.1 EQUIPMENT

- A. Conductors, include grounding conductors, shall be stranded copper. Aluminum conductor and/or solid conductor wire and cable will not be permitted. Insulation shall bear the UL label, the manufacturer's trademark, and identify the type, voltage, and conductor size. Conductors except flexible cords and cables, fixture wires, and conductors that form an integral part of equipment such as motors and controllers shall conform to the requirements of Article 310 of the National Electric Code, latest edition, for current carrying capacity. Flexible cords and cables shall conform to Article 400, and fixture wires shall conform to Article 402. Wiring shall have wire markers at each end.
- B. Low Voltage Power and Lighting Wire

1. Wire rated for 600 volts in duct or conduit for power and lighting circuits shall be single conductor. Single, stranded, copper conductor cable conforming to ASTM B 3 and B 8 with cross-linked polyethylene, cross-linked polyolefin, ethylene propylene insulation, rated 90 degree C in dry locations and 75 degree C in wet locations and listed by UL as Type XHHW, or XHHW-2 conforming to UL 44, Standard for Thermoset-Insulated Wires and Cables.
2. No wire smaller than #12 AWG shall be used for power and lighting wiring.
3. Conductors for feeders as defined in Article 100 of the NEC shall be sized to prevent a voltage drop exceeding 3 percent at the farthest outlet of power, heating and lighting loads, or combinations of such loads, and where the maximum total voltage drop on both feeders and branch circuits to the farthest connected load does not exceed 5 percent.
4. Wiring for 600 volt class power and lighting shall be as manufactured by **Okonite**, **General Cable**, **Southwire**, or equal.

C. Low Voltage Control Wire

1. Low voltage control wire in duct or conduit shall be the same type as power and lighting wire indicated above.
2. Control wiring shall be No.14 AWG Control wires within panels and cabinets shall be THHN/THWN dual rated, UL approved, rated for 90 degrees C at dry locations as manufactured by Southwire, Okonite, or approved equal.

D. Instrumentation Cable

1. Single Shielded Pair and Triad Instrument Cable:
 - a. Tinned copper, stranded conductors, No. 16 AWG minimum, color coded polyethylene insulation on twisted conductors with 100 % coverage aluminum-polyester shield, stranded and tinned No. 18 AWG minimum copper drain wire and overall PVC jacket. Rated for 300 volts minimum.
 - b. Color code of pairs shall be black and clear. Color code of triads shall be black, red, and clear.
 - c. Pair manufacturer and type:
 - 1) Belden No. 8719.
 - 2) Or approved equal.
 - d. Triad manufacturer and type:
 - 1) Belden No. 8618
 - 2) Or approved equal.

E. VFD Power Cable

1. VFD Cable shall be MC continuous corrugated armor type with shielded symmetrical grounds
2. VFD Cables shall be as manufactured by **Belden, Alpha, General Cable**, or equal.

2.2 CABLE TERMINATIONS

- A. Compression connectors shall be Burndy "Hylug", T&B Sta-Kon, or approved equal. Use manufacturer recommended indent compression or circumferential compression tools (preferred). Pressure type, twist-on connectors (wire nuts) will not be acceptable..
 1. For all wiring, use compression connectors .
 2. For wire sizes 250 kcmil and larger where indent connectors are used, provide at least two (2) compression indents. Provide lugs with provision for at least 2 bolts (2 hole lugs) for connecting to apparatus.
- B. Pre-insulated fork tongue lugs shall be "Thomas & Betts" RC Series, Burndy, or approved equal.
- C. General purpose insulating tape shall be Scotch No. 33, Plymouth "Slip-knot", or approved equal. High temperature tape shall be polyvinyl as manufactured by Plymouth, 3M, or approved equal.
- D. Wire Identification
 1. Heat Shrinkable Wire and Cable Labeling System:
 - a. White heat-shrinkable irradiated polyolefin shrink-on sleeves. Labels shall be thermal printed. Labels shall be at least 2 inches in width.
 - b. Products and Manufacturers:
 - 1) B-341 PS-xxx-2W by Brady.
 - 2) Or approved equal.
 2. Wrap-Around Wire and Cable Labeling System:
 - a. Self-laminating white/transparent self-extinguishing vinyl strips. Length shall be sufficient to provide at least two and one-half wraps. Labels shall be thermally printed. Labels shall be at least 2-inches in width.
 - b. Products and Manufacturers:
 - 1) THT-XX-427 by Brady.
 - 2) Or approved equal.

PART 3 -- EXECUTION

3.1 INSTALLATION

A. General

1. The CONTRACTOR shall provide, install, and terminate all power, control, and instrumentation conductors except where specified in other sections.
2. All wires, cables and conduit wire fills shall conform to the regulations of the National Electric Code, latest edition, for current carrying capacity. All wiring shall have wire markers at each end.
3. The CONTRACTOR shall, as a minimum, provide the number of control wires listed in the conduit schedule or on the Contract Drawings. Excess wires shall be treated as spares for future use.
4. Unless otherwise specified or shown, install all wire and cable in conduit. Conductors shall not be pulled into any raceway until raceway has been cleared of moisture and debris.
5. Pulling tensions on raceway cables shall be within the limits recommended by the cable manufacturer. Wire pulling lubricant, where needed, shall be UL approved.
6. Instrumentation wire shall not be run in the same raceway with power and control wiring except where specifically indicated.
7. Wire in panels, cabinets, and wireways shall be neatly grouped using nylon tie straps, and shall be neatly fanned out to terminals.
8. Intrinsically safe wiring shall be run in a raceway dedicated as intrinsically safe and utilized exclusively for the intrinsically safe wiring.
9. Provide separation for data cables in accordance with equipment manufacturer and industry recommendations, especially regarding separation from low- and medium-voltage power.
10. Where required for installation of cables under this Contract, the CONTRACTOR shall be responsible for dewatering electrical manholes. When working in manholes, the CONTRACTOR shall ensure that only personnel trained in confined space entry are allowed to work in the manholes. The CONTRACTOR shall fill out OWNER paperwork for each entry.
11. Bending Radius: To be limited to 6 times cable overall diameter, minimum except where the NEC requires a larger minimum limit.
12. Single conductor cable in cable trays shall be No. 1/0 or larger and shall be of a type listed and marked for use in cable trays. Tray cable smaller than 1/0 shall be multi-conductor, with outer jacket.

B. Splices and Terminations

1. In general, there shall be no cable splices except as specifically permitted or indicated. Where required, splice control wiring in junction box using terminal blocks. Splices in conduits or condulets are not permitted. Power cable splices

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shall be submersible. Provide terminal blocks in NEMA 4X enclosures for extension of existing signal/instrument and control cables.

2. All wire taps and splices shall be properly taped and insulated as to their respective classes and shall meet the requirements of A.S.T.M.
3. Stranded conductors shall be terminated directly on equipment box lugs making sure that all conductor strands are confined within lug. Use forked-tongue lugs where equipment box lugs have not been provided.
4. Excess control and instrumentation wires shall be long enough to terminate at any terminal block in the enclosure, be properly taped, be identified as spare with origin, and be neatly coiled.
5. In general, there shall be no cable splices in underground manholes/handholes/pull boxes. Wire taps and splices shall be properly taped and insulated according to their respective classes. If splices are necessary, the cables shall be spliced using submersible cable splices, suitable for continuous submergence

C. Control Wire and Cable

1. Control conductors shall be terminated only at the locations shown and only on terminal strips or terminal lugs of vendor furnished equipment. There shall be no splicing of control conductors.
2. In motor control centers, and control panels/stations, all control wire and excess wire shall be terminated to terminal strips.
3. In junction boxes connecting three or more conduits, all control wiring that is distributed to three or more of the conduits shall be terminated to terminal strips. All control wiring that is included in two conduits only (pulled through only), shall not be terminated. All excess wiring shall be terminated to terminal strips.
4. In junction boxes serving as an interface to the factory wiring of equipment or field devices, all control wiring shall be terminated to terminal strips. Examples include, but are not limited to, leads from the equipment or device that are connected internally (no accessible terminal strip) or field installed cable assemblies that interface to the equipment or device (plug in connectors specific to the equipment). All excess wiring shall be terminated to terminal strips.
5. The CONTRACTOR shall provide as a minimum the number of control wires listed in the conduit schedule or as indicated in the Contract Documents. Excess wires shall be treated as excess.

D. Instrumentation Wire and Cable

1. Shielded instrumentation cables shall be grounded at one end only, preferably the receiving end on a 4 - 20 mA system such as the PLC cabinet. Opposite end is to be isolated.
2. Single pair and triad shielded cables installed in conduit runs which exceed 2,000 feet may be spliced in pullboxes. These cable runs shall have only one splice per conductor. All splices, including shields, shall be made using terminal blocks.

3. Shield wires are to be terminated in panels on their appropriate terminal, with their corresponding circuits.
4. Instrumentation terminations shall be no more than 1-1/2" exposed outside of shield; shields shall be individually terminated; and the drain wire shall be no longer than 2"

E. Power Wire and Cable

1. 120/208-volt, and 480V-volt branch circuit conductors may be spliced in suitable fittings at locations determined by the CONTRACTOR.
2. Splices to motor leads in motor terminal boxes shall be wrapped with mastic material to form a mold and then shall be taped with a minimum of 2 layers of varnished cambric tape overtaped with a minimum of 2 layers of high temperature tape.
3. Shielded power cable shall be terminated with pre-assembled stress cones in a manner approved by the cable and terminal manufacturer. The CONTRACTOR shall submit the proposed termination procedure as a Shop Drawing.
4. VFD shielded power cables shall have the shield grounded at all locations where it is exposed.

F. Cable Identification

1. General: The completed electrical installation shall be provided with adequate identification to facilitate proper control of circuits and equipment and to reduce maintenance effort, all as specified below.
2. Wire and Terminal Labeling System:
 - a. All wire shall be labeled using heat, oil water and solvent resistant, vinyl, self-laminating, self-adhesive wrap type labels as manufactured by the W.H. Brady Co. or approved equal.
 - b. Wire and Cable Labels shall be provided as follows:
 - 1) New, rerouted, or revised wire or cable shall be labeled.
 - 2) All insulated conductors shall be labeled.
 - 3) Bare (uninsulated) conductors shall not be labeled unless otherwise shown or specified.
 - 4) Wire and cable terminations shall be labeled.
 - 5) Wire labels shall be applied between half an inch and one inch of the completed termination.
 - 6) Cable labels shall be applied between half an inch and one inch of cable breakout into individual conductors.
 - 7) Individual conductors in a cable shall be labeled after the breakout as specified for wires.
 - 8) Wire or cable exiting cabinets, consoles, panels, terminal boxes and enclosures shall be labeled.
 - a) Wires or cables shall be labeled within two inches of the entrance to the conduit.
 - 9) Wire or cable in junction boxes and pull boxes shall be labeled.

- a) Wires or cables shall be labeled within two inches of the entrance to the conduit.
 - 10) Wire and cable installed in cable tray shall be labeled.
 - a) Wire and cable shall have labels applied at 20 foot maximum intervals.
 - 11) Wire and cable installed without terminations in electrical manholes shall be labeled.
 - a) Wire and cable shall have wrap-around labels applied within one foot of exiting the manhole.
 - 12) Handwritten labels are not permitted.
- 3. Wire and Cable Identification System:
 - a. Wire and Cable labels shall be imprinted with an identifying designator.
 - 1) Wire and cable extending between two devices or items, and which does not undergo a change of function shall be identified by a single unique designator as specified below.
 - b. All panel wires and field wires shall be color-coded and have an alphanumeric identification tag at each point of termination.
 - 1) Wire within conduits accessible by removing covers of junction boxes and other devices in the conduit system shall be labeled.
 - c. Wiring terminated at a Cabinet, Console, Panel and Enclosure (no PLC).
 - 1) The wire designator shall consist of an assigned alpha numeric designator.
 - 2) Cables shall be labeled using the equipment/instrument tag number.
 - 3) All terminals and terminal strips and posts shall be numbered with Mylar applique number labels.
- 4. Cable: The CONTRACTOR shall label each control and instrumentation wire with the unique identification numbers as specified herein and in accordance with Section 26 05 53 – Electrical Identification. If an identification number/method is not specifically shown, the CONTRACTOR shall assign a unique identification number with the same convention and in sequence with conductors of related equipment. Said numbers shall be assigned to all conductors having common terminals and shall be shown on all "record" drawings.
 - a. Terminate all field wiring at copper barrier type terminal blocks with clear covers for terminals. For internal panel wiring barrier type terminal blocks are acceptable for power distribution only, otherwise DIN rail style terminal blocks shall be used. All DIN style terminal blocks, including those for plug-in relays and other devices, shall have finger-safe terminals. Barrier type terminal blocks shall have clear covers over terminals.
 - b. No more than two wires shall be terminated at any single screw. Provide jumpers as required to join adjacent terminal blocks for additional wiring connection points.
 - c. All terminal strips shall be labeled with permanently affixed numeric identifiers on each block. Identifiers shall be self-stick plastic tape strips with permanent, machine printed numbers.

- d. Provide a separate terminal block for landing each analog signal cable shield.
- e. Provide separate terminal strips for DC signal and AC power wiring.
- f. All excess cable shall be terminated on terminal strips and shall be identified with a unique number as well as with destination.

5. Color Coding:

- a. Identification: Identify all conductors by circuit number and phase at each terminal location. Color code conductors as follows:
 - 1) 120/208 Volt Systems (includes control power):
 - a) Three Phase: Black (Phase A), Red (Phase B), Blue (Phase C), White-Neutral.
 - 2) 120/240 Volt Systems (includes control power):
 - a) Single Phase: Black (Phase A), Red (Phase B), White-Neutral.
 - 3) 480/277 Volt Systems: Brown (Phase A), Orange (Phase B), Yellow (Phase C); Gray – Neutral
 - 4) AC Control Wiring: Red.
 - 5) DC Control Wiring: For (+) DC control wiring blue. For (-) DC control wiring white with blue trace.
 - 6) Conductors that remain energized when main disconnecting means is off: Yellow.
 - a) For all panels containing wiring not de-energized by the panel disconnect or circuit breaker, provide a warning nameplate on the front of the panel stating "WARNING YELLOW WIRING NOT DE-ENERGIZED BY PANEL DISCONNECT." The nameplate shall be amber with black, 1/4 inch high letter engravings and shall be attached to the panel face with stainless steel screws.
 - 7) Grounding Conductors: Green.
- b. Cable color to be continuously applied by manufacturer.
- c. Colored insulation shall be used. Color coding by means of tape or similar means shall not be permitted. Color coding and phasing shall be consistent throughout the site, bus bars at panelboards, switchboards, and motor control centers shall be connected Phase A-B-C, top to bottom, or left to right, facing connecting lugs. Manhole cable identifications shall be permanent in submerged conditions.

3.2 FIELD QUALITY CONTROL

- A. Testing shall conform to the requirements of Section 01 75 16 – Equipment and System Start Up and Testing, 26 01 26 – Electrical Tests and those specified in this Section.
- B. Cable Assembly and Testing: Cable assembly and testing shall comply with applicable requirements ICEA Publication No. S-68-516 and other relevant ICEA Publications. Factory test results shall be submitted in accordance with Section 01 33 00 – Submittal Procedures, prior to shipment of cable. All field testing shall be witnessed by the OWNER. The following field tests shall be the minimum requirements:
 - 1. All new and existing low voltage power cables affected by this project shall be tested for insulation resistance between phases and from each phase to a ground using a

megohmmeter. The tester shall be supplied by the CONTRACTOR. Battery driven testers will be acceptable.

2. All field testing mentioned above shall be done after cables are installed in the raceways.
 3. Field tests shall be performed by certified test organization acceptable to the OWNER. Test results shall be submitted to the OWNER for review and acceptance.
 4. New cables failing in the said tests shall be replaced with a new cable or repaired. Such kind of repair methods shall be as recommended by the cable manufacturer and shall be performed by persons certified by the industry. Where existing cables fail, the CONTRACTOR shall notify the OWNER immediately for corrective action.
- C. Continuity Test: All control and instrumentation cables shall be tested for continuity, polarity, undesirable ground, and origination. Such tests shall be performed after installation and prior to placing all cables in service. Under no circumstances shall Megger tests be made to control wiring connected to control panels or instruments.

END OF SECTION

SECTION 26 05 26 – GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

PART 1 -- GENERAL

1.01 SUMMARY

A. Section Includes

1. This section includes specifications for products, specific criteria and characteristics, methods and execution for electrical system grounding and equipment bonding, including but not limited to: grounding electrode systems, equipment grounding systems and bonding systems.

1.02 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

A. Reference Specifications

01 33 00	Submittal Procedures
26 00 10	Electrical General Requirements
26 01 26	Electrical Tests

B. Reference Standards

Institute of Electrical and Electronics Engineers (IEEE)	
IEEE 80	Guide for Safety in AC Substation Grounding
IEEE 81	Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Grounding System
IEEE 837	Qualifying Permanent Connections Used in Substation Grounding
IEEE 3003 (all)	Power Systems Grounding (all)
Underwriters Laboratories (UL)	
UL 467	Grounding and Bonding Equipment
InterNational Electrical Testing Association (NETA)	
NETA ATS	Standard for Acceptance Testing Specifications for Electrical Power Equipment and Systems

C. Reference Codes

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)	
NFPA 70	National Electric Code, 2023 Edition

1.03 SUBMITTALS

A. General

1. Submittals in accordance with Section 01 33 00 – Submittal Procedures and Section 26 00 10 – Electrical General Requirements. Submit grounding test reports in accordance with this section as well as Section 26 01 26 – Electrical Tests.

B. Product Data

1. Submit product data sheet for each type of grounding conductor, electrode, connection, termination, fitting and accessory.

C. Shop Drawings

1. Submit scaled and dimensioned layout drawings of buried and exposed grounding systems. Provide details of interconnections, grounding electrodes (including UFER grounds), grounding electrode conductors, risers, pigtails, terminations and related information.

D. Testing Company/Personnel Qualifications and Certifications

1. Submit data demonstrating training, qualifications and certifications of the independent test company and personnel performing the field testing of the grounding systems.

E. Test and Evaluation Reports

1. Submit test forms as specified in Section 26 01 26– Electrical Tests.

F. Field or Site Quality Control Submittals

1. Submit documentation of successful testing, including completed test forms, as specified in Section 26 01 26 – Electrical Tests. Where testing does not meet specified requirements, submit details of failed test results, corrective actions performed and successful re-test results.

1.04 CLOSEOUT SUBMITTALS

A. General

1. Submittals in accordance with Division 01 and Section 26 00 10 – Electrical General Requirements.

B. Record Documentation

1. As-built drawings.
2. Completed test forms.

1.05 DELIVERY, STORAGE, AND HANDLING

- A. CONTRACTOR shall handle and store the products in accordance with the manufacturer's written requirements.
- B. Inspect and report any concealed damage or violation of delivery, storage, and handling requirements.

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PART 2 -- PRODUCTS

2.01 MANUFACTURERS, OR EQUAL

- A. Burndy
- B. Thomas and Betts
- C. nVent Erico
- D. Blackburn

2.02 MATERIALS

- A. Rod electrodes: copper-clad steel, 3/4" diameter, 10 ft long.
- B. Plate electrodes: copper, minimum 24" x 24 surface area 1/4" thick.
- C. Ground test wells: Schedule 80 PVC with cast iron cover in non-traffic areas; reinforced concrete with cast iron cover (H-20 rated) in traffic areas. Cover shall read "GROUND" or "GROUND TEST WELL".
- D. Copper bare stranded conductor, sizes as indicated or larger as required by code (minimum #2 AWG), for buried ground grid and ground bus, and grounding electrode interconnections.
- E. XHHW-2 green insulated stranded copper conductor, sized in accordance with NEC, for system grounding and equipment bonding connections.
- F. Tinned copper bare stranded conductor, sizes as indicated or larger as required by code (minimum #2 AWG), for bonding of ground bus, metal structures, gradient control mats, transformers, switchgear, switchboard, MCC, panelboards, motors frames, etc.
- G. Copper bare stranded conductor, sized in accordance with NEC, minimum #2/0 AWG, for continuous cable tray bonding.
- H. XHHW-2 green insulated stranded copper conductor, minimum #6 AWG, for grounding cable sheaths, raceways, pipe work, screen guards, and voltage transformers.
- I. XHHW-2 green insulated stranded copper conductor, minimum #10 AWG, for grounding meter, relay cases, and ground rod test system.
- J. Extra flexible copper braid conductor, sizes as indicated or larger as required by code (minimum #2/0 AWG equivalent size), for connection of switch mechanism operating rod to gradient control mat, fences and fence gates, vault doors, and electrical room doors and windows.
- K. Ground bus: tin-plated copper, 2" x 1/4" x 24" minimum size, complete with insulated supports, fastenings and connectors.
- L. Bolted removable test links for connection to ground of any distribution center neutral buses and building non-current carrying metal surfaces.
- M. Gradient control mat: galvanized steel, minimum size 6' x 4', 6" x 6" x 1/4" mesh

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- N. Compression connectors: ANSI/IEEE and UL approved, non-corrosive, high strength, irreversible compression system:
1. Compression grounding taps and connectors (Burndy "Hyground" YGHP-C, YGHR-C, YGHC-C, YGL-C/YGLR-C or equivalent) for connection of buried or otherwise inaccessible grounding conductor to rod electrode or other grounding electrode conductor. Exothermic copper welding connections (Cad Weld) for connection of buried or otherwise inaccessible grounding conductor to rod electrode or other grounding electrode conductor.
 2. Compression grounding connector (Burndy YGIB or equivalent) 2-hole compression terminal (Burndy YGHA or equivalent) for accessible connections of bonding/grounding conductor to the building structural steel members above ground. Where approved by the Engineer and where inaccessible, welding grounding stud connector (Burndy GSTUD-HY or equivalent) compression grounding connector (Burndy YGHP-C or equivalent) for connection of bonding/grounding conductor to the building structural steel members above ground.
 3. Compression grounding plates (Burndy YGF-2N/4N or equivalent) for connection of bonding/grounding conductor to the building structural steel members direct buried or encased in concrete.
- O. Mechanical connectors, UL approved, non-corrosive, high strength (Burndy "G" series or equivalent) for connection of bonding/grounding conductor to cable tray, and U-bolt clamp connector for connection of bonding/grounding conductor to electrical raceways, metallic piping, fence, posts, etc.
- P. Accessories: non-corroding, necessary for complete grounding system, type, size material as required, including but not limited to: grounding and bonding bushings, protective type clamps, direct bury-rated compression connectors, bonding jumpers, straps, etc.
- Q. Armoured cable sheath isolating plates, non-conducting fiber 1/2" thick, or non-magnetic aluminum 3/8" thick.

PART 3 -- EXECUTION

3.01 INSTALLATION

A. General Installation

1. Install and test the complete continuous grounding system including, electrodes, conductors, connectors and accessories in accordance with UL 467 and the NEC, and the contract documents.
2. Protect exposed grounding conductors from mechanical damage with Schedule 80 PVC conduit at ground level or where penetrating concrete. Provide additional mechanical protection where required.

3. Make buried connections and connections to electrodes, structural steel work, using permanent, irreversible compression connectors to ANSI/IEEE 837. Connectors shall be listed for use in direct-bury applications. Where necessary to ensure a low impedance connection, mechanically clean metal surfaces to bare, smooth metal. After the connection is made and tested, re-coat the metal surface to match the original.
4. Exothermic copper welding process is only permitted under the direct and immediate supervision of the manufacturer's representative, or demonstrable expertise acceptable to the Engineer.
5. Use mechanical connectors for grounding/bonding connections to equipment provided with lugs. Bolted connections shall be tightened to the manufacturers' specifications using a torque wrench or vendor-recommended tools.
6. Use tinned copper conductors for aluminum structures.
7. Do not use bare copper conductors near jacketed lead sheath cables.
8. Make grounding connections in radial configuration only, with connections terminating at single grounding point at the line end of the circuit.
9. Install connectors in accordance with manufacturer's instructions.

B. Ground Grid and Electrodes

1. Install ground rod electrodes 12" below finished grade; install plate electrodes 24" below finished grade. Unless otherwise indicated:
 - a. Provide not less than four (4) interconnected rod electrodes, one (1) at each corner of a structure and spaced not more than 100 feet apart, 3 feet offset of buildings, outdoor substations, outdoor transformers; outdoor equipment racks, outdoor generators and outdoor switchgear. Offset distance shall be 18" inside and outside of substation metal fences and inside-only for metal fences not surrounding substations.
 - b. Provide three (3) interconnected rod electrodes at pole-mount switching devices and pole-mounted transformers. Arrange rods in triangular formation with 10 foot sides, located so that operator must stand within the triangle to operate the switch.
 - c. Provide single rod electrode, 3ft offset at each: light pole, underground manhole/underground pullbox.
2. Install a horizontal ground grid, 1ft below finished grade, by interconnecting all grounding electrode conductors in a square pattern, spaced 3 ft apart in each direction. Connect grid conductors at each intersection.

- C. Where indicated on the drawings, install concrete encased electrodes (UFER) in building foundation footings with a connection to the buried grounding electrode system network. UFER grounds shall not be installed with buildings utilizing foundation vapor barriers that prevent foundation contact with the surrounding earth.

- D. Contractor shall make special provision for installing electrodes that will give acceptable resistance to ground value, where rock or sand terrain prevails, or space is limited.

E. Ground Bus

1. Install tin-plated copper grounding bus mounted on insulated supports on wall of electrical rooms where indicated.
2. Ground items of electrical equipment in electrical room to ground bus with individual bare stranded tinned copper conductors. Equipment that requires an isolated ground connection shall be made directly to the grounding electrode system or to a dedicated/isolated ground bus.

F. System and Circuit Grounding

1. Install system and circuit grounding connections to neutral of all power and distribution transformers, and generators, as required by Code and as indicated on the drawings. System connection to transformer neutral shall be at one location only.
2. Connect transformer neutral and distribution neutral together using full system voltage rated insulated conductors to one side of ground test link, the other side of the test link being connected directly to main station/system ground.
3. Ensure neutrals of voltage transformers are bonded directly to their respective transformer neutral and not to main station/system ground.
4. Provide grounded conductors of size and quantity in accordance with NEC, unless indicated to be larger on the drawings.

G. Equipment Bonding

1. Install bonding connections as required by Code and as indicated on the drawings. Connections shall include but not limited to: metallic water mains and metallic piping systems; non-current carrying metal parts and frames of electrical equipment and motors; metallic cable-sheaths, raceways, cable trays, wireways; any exposed building metal within or forming part of a structure, rebar and building steel, metal ladders/stairs/grating; outdoor lighting; elevators; and metallic process equipment and HVAC equipment/ductwork. Provide supplemental ground connections to motor shaft grounding rings.
2. Provide bonding conductors of size and quantity in accordance with NEC, unless indicated to be larger on the drawings.
3. Provide equipment grounding conductors in all raceways (metallic and non-metallic). The raceway shall not be used as the sole means for providing equipment grounding and bonding connections.
4. Connect grounding grid in two (2) locations to equipment grounding bus located in the electrical rooms, power transformers, generators, switchgear, motor control centers, switchboards, and all medium and high voltage equipment.

5. Where crossing expansion joints, provide raceways with external flexible braided bonding jumpers.
6. Connect electrical room metallic hinged doors to ground with flexible jumper.

H. Cable Sheath Grounding / Bonding

1. Use approved cable and conduit connectors to terminate cables complete with grounding bushings.
2. Bond multi-conductor metallic sheathed cables at each end.
3. Bond single-conductor metallic sheathed cables 425A or less, together at each end; over 425A together at one end only (line end). Use aluminum board for eddy current prevention at each end. Break sheath continuity at load end by using sheath insulating sleeves or non-conducting fiber-board for cables over 425A.
4. Connect bonded cables to ground.

I. Communications and Special Systems

1. Provide grounding and bonding connections for telephone, instrumentation, intercom, fire alarm, and other special systems in accordance with the equipment manufacturer's written requirements.
2. Provide telephone grounding system in accordance with local telephone company's requirements.

J. Field Quality Control

1. Before energizing electrical systems, perform grounding system resistance tests using method appropriate to site conditions, as approved by the Engineer and local authority having jurisdiction.
2. Perform grounding and bonding continuity tests.

3.02 SITE QUALITY CONTROL

A. Provide site quality control and commissioning in accordance with Section 26 01 26 - Electrical Tests, and as described herein.

B. Field Tests and Inspections

C. Visual and Mechanical Inspection

1. Inspect for physical and mechanical condition and check for proper mounting, anchorage, and grounding.
2. Inspect electrical connections for high resistance by verifying tightness using calibrated torque wrench in accordance with published manufacturer's data.

D. Electrical Tests: Provide grounding system tests in accordance with Codes and IEEE 81 requirements. Grounding systems to be tested include, but are not limited to:

1. Test Wells.

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2. Ground rods and grounding electrode conductors.
 3. Ground rings and grounding electrode conductors.
 4. Grounding arrangements and connections for services and separately derived systems.
 5. Provide supplemental grounding and grounding electrodes where measured ground resistances exceed the following values:
 - a. Power and Lighting Equipment or System with Capacity of 500 kVA and Less: 10 ohms.
 - b. Power and Lighting Equipment or System with Capacity of 500 to 1000 kVA: 5 ohms.
 - c. Power and Lighting Equipment or System with Capacity More Than 1000 kVA: 3 ohms.
 - d. Power Distribution Units or Panelboards Serving Electronic Equipment: 3 ohms.
 - e. Substations and Pad-Mounted Equipment: 5 ohms.
 - f. Manhole Grounds: 10 ohms.
- E. Non-Conforming Work
1. Correct all non-conforming work.
 2. Re-test and obtain re-inspection.

3.03 CLEANING

- A. Prior to testing ensure all components are cleaned and free of dust.
- B. After testing, protect components from dust and construction activities.

END OF SECTION

SECTION 26 05 33- ELECTRICAL RACEWAY SYSTEMS

PART 1 -- GENERAL

1.1 THE REQUIREMENT

- A. The CONTRACTOR shall furnish and install, at the locations shown on the Contract Drawings, as specified or as directed, the electrical raceway systems, complete with shop drawings, operation and maintenance manuals, and other appurtenances, and furnish all labor, supervision, materials, appurtenances, tools and ancillary services as required for a complete and operable installation in accordance with the requirements of the Contract Documents.
- B. AThe requirements of the drawings and General Conditions of the Contract, including Special Conditions and Division 01 Specification sections, apply to the work of this Section.
- C. The requirements of the following section(s) also apply to work in the Section:
 - 1. Section 26 00 10 – Electrical General Requirements.
- D. Single Manufacturer: Like products shall be the end product of one manufacturer in order to achieve standardization of appearance, operation, maintenance, and manufacturer's services.

1.2 REFERENCE STANDARDS

- A. NEC Article 300, Wiring Methods.
- B. NEC Article 346, Rigid Metal Conduit.
- C. NEC Article 347, Rigid Nonmetallic Conduit.
- D. NEC Article 351, Liquidtight Flexible Metal Conduit.
- E. NEC Article 356 – Liquidtight Flexible Nonmetallic Conduit
- F. NEC Article 370, Outlet, Switch and Junction Boxes and Fittings.
- G. UL Standard No. 6, Rigid Metal Electrical Conduit.
- H. UL Standard No. 6A, Rigid Metal Electrical Conduit – Aluminum, Red Brass, and Stainless Steel.
- I. UL Standard No. 50, Electrical Cabinets and Boxes.
- J. UL Standard No. 360, Liquid-Tight Flexible Steel Conduit.
- K. UL Standard 467, Electrical Grounding and Bonding Equipment.
- L. UL Standard 514, Electrical Outlet Boxes and Fittings.
- M. UL Standard 651, Schedule 40 and 80 PVC Conduit.

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- N. UL Standard 886, Electrical Outlet Boxes and Fittings for Use in Hazardous Locations.
- O. UL Standard 1660, Liquid-Tight Flexible Nonmetallic Conduit
- P. ANSI C80.1, Specification for Zinc Coated Rigid Steel Conduit.
- Q. ANSI C80.5, Specification for Rigid Aluminum Conduit.
- R. NEMA TC3, PVC Fittings for Use with Rigid PVC Conduit and Tubing.
- S. NEMA RN1, PVC Externally Coated Galvanized Rigid Steel Conduit and Intermediate Metal Conduit.
- T. IEEE 518, Guide for the Installation of Electrical Equipment to Minimize Electrical Noise Inputs to Controllers from External Sources.

1.3 CONTRACTOR SUBMITTALS

- A. Furnish submittals in accordance with Section 01 33 00– Submittal Procedures, and Section 26 00 10 – Electrical General Requirements.
- B. Shop Drawings
 - 1. Submit complete catalog cuts of raceways, fittings, boxes, supports, and mounting hardware, marked where applicable to show proposed materials and finishes.
 - 2. Submit dimensioned layout drawings of proposed embedded/encased raceway routings within concrete slabs.
 - 3. Submit dimensioned layout drawings of cable tray routings, including elevations
 - 4. As-Built Drawings
 - a. Prepare as-built drawings of encased concealed and exposed raceways, ducts, raceways, junction boxes, pull boxes, and electrical and instrumentation equipment.
 - b. Furnish the drawings to the ENGINEER in accordance with the requirements of Section 01 33 00 – Submittal Procedures.

PART 2 -- PRODUCTS

2.1 GENERAL

- A. Pull and junction boxes, fittings, and other indicated enclosures that are dedicated to the raceway system shall comply with the requirements of this Section.
- B. Gaskets shall be neoprene. Cork gaskets will not be permitted.
- C. All boxes and fittings shall utilize 316 stainless steel hardware.

2.2 CONDUIT

- A. **Aluminum Conduit:**

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1. Aluminum Conduit, Elbows and Couplings:

- a. Material: Rigid, heavy wall 6063 alloy, temper T-1 aluminum, smooth interior, tapered threads and carefully reamed ends; ¾ inch NPS minimum size.
- b. For all exposed runs (hazardous and non-hazardous areas), except in Ferric Chloride areas.
- c. Joints: Threaded with lubricant by Burndy Pentrox or approved equal.
- d. Rigid aluminum conduit shall be manufactured in accordance with ANSI C80.5 – Rigid Aluminum Conduit, and UL-6A – Rigid Metal Electrical Conduit – Aluminum, Red Brass and Stainless Steel.
- e. Manufacturer, or Equal
 - 1) V.A.W. of America
 - 2) Alcoa
 - 3) Or approved equal

2. Aluminum Conduit Fittings and Outlet Bodies:

- a. Material and construction: Cast copper-free aluminum bodies and covers with stainless steel screws. All units are to have gaskets and be watertight. Gaskets shall be neoprene. Improvised gaskets and cork gaskets are not acceptable. All units are to be the threaded type with five full threads. Material is to conform to ANSI and be listed by UL. The use of 'LB' fittings shall be avoided and type 'LBD' fittings applied wherever the use of fittings is unavoidable.
- b. Manufacturer: Provide aluminum conduit fittings and outlet bodies from one of the following:
 - 1) Crouse-Hinds Co.
 - 2) Appleton Electric Co.
 - 3) Or approved equal.

B. Non-Metallic Conduit:

1. PVC Plastic:

- a. Material: Schedule 80 PVC plastic, NEMA Type EPC-80-PVD, 90 deg. C rated, conforming to UL No. 651.
- b. For buried and concrete encased ductbank runs and ferric chloride areas (except Analog signal, instrumentation or communication conduit encased in floor slab or duct bank shall be PVC-coated RGS).
- c. PVC Fittings and Boxes:
 - 1) For use with rigid non-metallic PVC conduit, provide fittings manufactured solvent-welded PVC.

- 2) Provide boxes manufactured of PVC or fiberglass reinforced polyester (FRP).
- 3) Provide welding solvent as required for the installation of non-metallic conduit and fittings.
- d. Manufacturer: Provide non-metallic conduit from one of the following:
 - 1) **Amoco Chemicals Corporation.**
 - 2) **Carlton, Division of Indian Head, Incorporated.**
 - 3) **Or approved equal.**
- 2. Fiberglass Reinforced Plastic (FRP) Rigid Non-Metallic Conduit:
 - a. Provide FRP elbows, conduits and couplings when transitioning from concrete encased PVC to exposed aluminum in non-hazardous/non-classified areas or outdoors. Thread adapters and PVC adapters shall be factory installed where factory elbows are utilized.
 - b. Provide iron pipe size (IPS) FRP conduits .
 - c. Provide suitable joint adhesive epoxy for the application
 - d. FRP conduit shall be UL listed (UL 1684 - Standard for Safety for Reinforced Thermosetting Resin Conduit (RTRC) and Fittings)
 - e. Manufacturer: Provide fiberglass conduit from one of the following:
 - 1) **Champion Fiberglass.**
 - 2) **Or approved equal.**
- 3. Non-Metallic Fittings: Form elbows, bodies, terminations, expansions and fasteners of same material and manufacturer as base conduit. Provide cement by same manufacturer as base conduit.

C. Liquid-Tight Flexible Conduit (non-hazardous):

- 1. Material: Flexible galvanized steel core with smooth, abrasion-resistant, liquid-tight, polyvinyl chloride cover. Continuous copper ground built in for sizes ¾ inch through 1-1/4 inch. Material shall be UL listed. An exterior bonding strap will be installed on all installations 1-1/2" or greater.
- 2. Product and Manufacturer: Provide conduit from one of the following:
 - a. **Sealtite UA by Anaconda Metal Hose Division, Anaconda American Brass Company.**
 - b. **Liquatite Type L.A. by Electric-Flex Company.**
 - c. **Or approved equal.**

D. Electrical Metallic Tubing (EMT) or Intermediate conduit (IMC) will not be accepted.

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1. **All conduit, elbows and fittings shall be manufactured in the U.S.A. and marked as such.**

2.3 FITTINGS AND BOXES

A. General

1. All cast fittings for use with metallic conduits shall be of the threaded type (five full threads).
2. All fittings and boxes shall have neoprene gaskets and non-magnetic stainless steel screws. All covers shall be attached by means of holes tapped into the body of the fitting. Covers and gaskets are to be by the same manufacturer as the box. Covers for fittings attached by means of clips or clamps are not acceptable.
3. The use of "LB" fittings shall be avoided and type "LBD" fittings applied where fittings are required.
4. Conduit shall be held in place with 316 stainless steel clamps, except in Ferric Chloride areas where PVC coated galvanized steel clamps shall be used. Galvanized or mild steel will not be acceptable as an alternate to stainless steel.

B. Flexible Conduit Fittings (non-hazardous areas):

1. Material and Construction: Malleable iron with cadmium finish. Fittings shall adapt the conduit to standard threaded connections, shall have an inside diameter not less than that of the corresponding standard conduit size and shall be UL listed. Fittings shall be vibration proof and weatherproof with captive O-ring seal.
2. Fittings for use with LFNC shall meet the requirements of paragraph 2.2.F above.
3. Manufacturer: Provide flexible conduit from one of the following:
 - a. **Crouse-Hinds Company.**
 - b. **Appleton Electric Company.**
 - c. Or approved equal.

C. Expansion Fittings:

1. Provide expansion fitting as **O.Z. Gedney Type DX** for expansion/deflection (or AX where written permission is provided for expansion only fitting), **Crouse Hinds Type XD** for expansion/deflection (or XJ where written permission is provided for expansion only fitting), or approved equal.
2. Stainless steel clamps and tinned copper braid bonding jumper. Fitting to be watertight, corrosion-resistant UL listed and compatible with the conduit system .

D. Device Boxes and Outlet Boxes

1. Non-Hazardous and/or Non-Corrosive Areas:
 - a. Material:

- 1) Surface Mounted: Cast copper-free aluminum.
- 2) Non-metallic PVC in ferric chloride areas.
- b. Provide deep boxes (FD or equivalent). Shallow boxes (FS) shall not be used
- c. Device Cover Plates:
 - 1) Cast copper-free aluminum.
 - 2) Stainless steel screws and hardware.
 - 3) Neoprene gaskets. Improvised or cork gaskets are not acceptable.
 - 4) Covers and gaskets are to be by the same manufacturer as the box.
 - 5) Provide PVC coated RGS fitting covers to replace existing fitting covers in the ferric chloride room.
- d. Manufacturers:
 - 1) **Appleton Electric Company.**
 - 2) **Crouse-Hinds Company.**
 - 3) Or approved equal.

E. Junction and Pull Boxes (12" x 12" and smaller):

1. Materials and Construction:

- a. NEMA 4X, 316 stainless steel (all non-hazardous areas, except ferric chloride areas). Use NEMA 4X, fiberglass or PVC bodies and covers in ferric chloride areas only.
- b. Neoprene gaskets. Improvised gaskets and cork gaskets are not acceptable.
- c. Stainless steel cover screws.
- d. External mounting lugs.
- e. Boxes shall be provided with no knockouts.
- f. Boxes shall be constructed with welded seams and covers.
- g. Boxes where conduits enter a building below grade shall have ½ inch drain hole with a petcock type fitting attached for ½ inch tubing drain line. Provide ½ inch drain line and fittings of polyethylene tubing to nearest drain trench or sump.

2. Manufacturer: Provide pull and junction boxes of one of the following:

- a. **Hoffman**
- b. Or approved equal.

F. Junction and Pull Boxes (larger than 12" x 12"):

1. Materials and Construction:

- a. NEMA 4X, 316 stainless steel, except in ferric chloride areas where FRP boxes shall be used.
- b. Neoprene gaskets. Improvised gaskets and cork gaskets are not acceptable.
- c. Stainless steel cover screws.
- d. External mounting lugs.
- e. Boxes shall be provided with no knockouts.
- f. Boxes shall be constructed with welded seams and covers.
- g. Boxes larger than 12" x 12" shall have hinged doors. All clamps shall be stainless steel with stainless steel screws.

2. Manufacturer: Provide pull and junction boxes of one of the following:

- a. **Hoffman**
- b. Or approved equal.

G. Conduit Hubs:

1. Material: Threaded conduit hub, vibration proof, weatherproof with captive O-ring seal, copper-free aluminum with insulated throat. PVC coated hubs shall be used in ferric chloride areas.
2. Use: Provide for all conduit terminations to boxes, cabinets and other enclosures.
3. Manufacturer: Conduit shall be terminated with aluminum, rain-tight hubs with grounding bushing as manufactured by **Myers (Eaton Crouse-Hinds)** or approved equal. PVC coated hubs shall be **Robroy, Ocal**, or approved equal.

H. Thruwall Seals:

1. Material:

- a. Interior Walls: Use PVC sleeves with approved fire stop materials.
- b. Exterior Walls (Existing): Use Link Seals with stainless steel hardware, if the wall is 8" thick or greater, use (2) sets of link seals:
 - 1) CMU construction: Use PVC sleeve.
 - 2) Solid concrete construction: No sleeve is required.
- c. Exterior Walls : Use Link Seals or Thruwall Seals as manufactured by **OZ Gedney**, or approved equal.

I. Duct Sealant

1. Duct sealant shall be foam duct sealant such as Polywater FST or approved equal.

J. Supports:

1. Rigidly support conduits by clamps, hangers or strut channels. Standard support strut shall be 1-5/8" wide x 12 gage (.105", minimum). Support strut locations shall be 316 stainless steel, except in ferric chloride areas where FRP struts shall be used.
2. Support single conduits by means of one-hole pipe clamps in combination with one-screw back plates, to raise conduits from the support surface. Support multiple runs of conduits on trapeze type hangers with 316 stainless steel threaded hanger rods, except in ferric chloride areas where 304 stainless steel rods shall be used.. Rods shall be not less than 3/8-inch diameter.
3. All support hardware (nuts, bolts, washers, etc.) shall be manufactured from 316 stainless steel, except in ferric chloride areas where 304 stainless steel hardware shall be used..
4. For freestanding supports, provide back to back strut with post base anchored to floor. Support strut used shall be 316 stainless steel, except in ferric chloride areas where FRP strut shall be used..
5. All threads shall be coated with a conductive lubricant before assembly.
6. Joints shall be tight, thoroughly grounded, secure, and free of obstructions in the pipe. All conduit shall be adequately reamed to prevent damage to the wires and cables inside. Strap wrenches and vises shall be used to install conduit to prevent wrench marks on conduit. Conduit with wrench marks shall be replaced at no additional cost to the OWNER.

2.4 All pull and junction boxes shall be labeled as specified in this section and 26 05 53 – Electrical Identification.

PART 3 -- EXECUTION

3.1 GENERAL

- A. Raceways shall be installed between equipment essentially as shown. Raceway systems shall be electrically and mechanically complete before conductors are installed. Bends and offsets shall be smooth and symmetrical, and shall be accomplished with tools designed for this purpose and shall be made without flattening or kinking or shall be factory-preformed bends. Welding, brazing or otherwise heating of metallic conduit is not acceptable. Place the conduit such that cutting, bending, or displacing reinforcement from its proper location will not be required. Cut conduit square using a saw or pipecutter; de-burr cut ends.
- B. Where raceway routings are designated on plan views the CONTRACTOR shall follow those routings to the extent possible when installing new conduit.
- C. Routings shall be adjusted to avoid obstructions. Coordinate with all other trades prior to installation of raceways. Lack of such coordination shall not be an excuse for extra compensation, and removal and re-installation to resolve conflicts shall be at no extra cost to the OWNER.

- D. Where raceways are indicated but routing is not indicated, such as home runs or on conduit developments and schedules, raceway routing shall be the CONTRACTOR's choice and provided in strict accordance with the NEC as well as customary installation practice. (CONTRACTOR's choice must follow specification requirements. Ex: No encasing conduit on the bottom slab below grade. In addition CONTRACTOR's choice is not allowed for encasing conduits shown as exposed on conduit development. Any request to encase conduit shown as exposed on conduit development shall be in writing to the OWNER.).
- E. Support rod attachment for ceiling-hung trapeze and cable tray installations shall meet the material and seismic requirements outlined in Section 26 00 00 – Electrical Work, General.
- F. Exposed raceways shall be installed parallel or perpendicular to structural beams.
- G. Exposed conduits shall be 3/4" minimum trade size. Encased conduits shall be one-inch minimum trade size. Supports shall be installed at distances required by the N.E.C.
- H. Install all fittings such as hubs, bushings, clamps, hangers, reducers, unions, water and gas seals, drains, breathers, caps plugs, couplings, nipples and all other fittings that are required for the installations. Avoid moisture traps where possible; where unavoidable, provide junction box with drain fittings at conduit low point. Use suitable conduit caps to protect installed conduit against entrance of dirt and moisture. Immediately after pulling any wire, box and enclosure covers shall be installed.
- I. Welding conduits and fittings to structural steel are not permitted.
- J. Burning holes in any structural steel is not permitted.
- K. PVC-coated conduits shall be installed by personnel certified by the manufacturer of the PVC-coated conduits and fittings. Any damage to PVC-coated conduit finish shall be touched up using materials and methods as prescribed by the manufacturer.
- L. Exposed Conduit Installation:
 - 1. Provide exposed conduit manufactured of rigid aluminum (except for conduit containing only grounding system bonding conductors where routed in unclassified locations, provide Schedule 80 PVC conduit). New raceways in ferric chloride areas shall utilize PVC Schedule 80 conduits and fittings.
 - 2. All fastening hardware shall be 316 stainless steel.
 - 3. Provide 316 stainless steel conduit racks (FRP in ferric chloride areas) of suitable width, length and height and arranged to suit field conditions. Provide support at every eight feet minimum.
 - 4. Maintain 6 inches from hot fluid lines and 1/4 inch from walls using non-metallic spacers.
 - 5. All CMU through-wall penetrations shall be sleeved with PVC conduit.
 - 6. All interior wall through-wall penetrations shall be sleeved with PVC conduit.
 - 7. All supports shall be braced in an approved manner to prevent swaying and to provide rigidity.

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8. No conduits or raceways shall be fastened to the sides of hanger rods.
9. Do not fasten supports to piping, ductwork, mechanical equipment, or conduit.
10. Wooden plugs, plastic inserts or gunpower-driven inserts are not acceptable as a base to secure conduit supports.
11. Arrange conduit to maintain headroom and present a neat appearance.

M. Conduit Terminations:

1. Install insulated bushings on conduits entering boxes or cabinets, except on threaded hub type boxes. Conduit entries shall be on the sides or bottom of cabinets. Exceptions shall be approved by the OWNER prior to installation.
2. Locknuts may be used in NEMA 1 locations as defined under 26 00 10 Electrical General Requirements. All other locations shall utilize rain-tight hubs. Locknuts (where permitted) shall be used with sealing "O" rings.
3. If hubs are not used, and where locknuts are approved, provide locknut and sealing O-ring on outside of enclosure with a bushing and locknut on the inside.
4. Bushings are not to be used in lieu of locknuts.
5. Grounding bushings shall be installed on all metallic conduits.
6. Duct sealant shall be installed where required by NEC Article 300.

N. Non-metallic Conduit Installation:

1. During installation provide expansion/deflection fittings for expansion and contraction to compensate for temperature variations. Expansion fittings shall be watertight and of the type suitable for direct burial.
2. Make transition to PVC coated rigid steel (hazardous) or fiberglass (non-hazardous) conduit before making turn up to enclosures.
3. Provide watertight expansion/deflection fittings at all structural expansion joints.
4. Minimum spacing for supports shall be 5'.

O. Flexible Conduit Installation:

1. Limit flexible conduit length to six feet maximum.
2. Connections to lay-in type grid lighting fixtures shall be made using flexible metal conduit not exceeding 4 feet in length.
3. Connections to motors and other equipment subject to vibration shall be made with liquid-tight flexible conduits not exceeding 3 feet in length. Equipment subject to vibration which is normally provided with wiring leads shall be provided with a cast junction box for the make-up of connections. Provide bonding jumpers where required.

Q. Installation of Expansion/Deflection Fittings:

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4. Install expansion/deflection fittings where conduits cross structural expansion joints.
5. Install expansion/deflection fittings where conduit movement is expected in more than one dimension, and where conduits transition out of structures in locations where differential settlement may occur. Also, provide every 200' maximum on exterior exposed conduits (less than 200' where required by Code or manufacturer recommendation).
6. Provide expansion and expansion/deflection fittings compatible with the raceway to which they are installed.
7. Where the CONTRACTOR confirms with the OWNER that conduit movement is only in one dimension oriented in-line with the conduit, expansion fittings may be used in lieu of expansion/deflection fittings.

R. Installation of Outlet and Device Boxes:

1. To avoid mounting boxes directly on brick, masonry or concrete walls, provide suitable 1/2-inch (minimum) non-metallic spacers to prevent mounting back of box directly against wall.
2. Leave no open conduit holes in boxes.
3. Outlet boxes/bodies to have external mounting provisions. Back drilling will not be permitted.
4. Label each cable and/or wire in boxes and identify with durable tag as to what circuit the cable and/or wire is connected.

S. Installation of Pull and Junction Boxes:

1. Securely fasten boxes to walls or other structural surfaces with 1/2" spacing on which they are mounted. Provide independent supports where no walls or other structural surface exists. Supports shall be stainless steel or fiberglass.
2. Install pull boxes in runs so that there are no more than (3) 90 degree bends, runs exceeding 200 feet and where required to conform with the National Electrical Code.
3. Provide terminal blocks in junction boxes where cable terminations or splices are required. Terminal blocks are to be sized per the National Electrical Code.
4. Ceiling mounted enclosures are not to be permitted without the expressed written consent of the OWNER.

T. Pull and Junction Box Labeling System:

1. All pull and junction boxes shall be labeled with nameplates. Nameplates shall be engraved laminated plastic with black letters and numerals engraved on a white background and shall have beveled edges. Nameplates shall be engraved with characters 1" high on boxes larger than 12" x 12" and 1/2" high on boxes smaller than 12" x 12". Nominal size of nameplates shall be 2"x 6", except where larger sizes are required to contain all data required or where smaller is necessary to fit on the face size of a smaller junction box. Attach nameplates using stainless steel machine screws, drilled and tapped with thread seal, in order to maintain the NEMA rating of the enclosure.

U. Cable and Conductor Separation Requirements:

1. Follow the minimum standards of the latest publication of IEEE 518, Paragraph 6.4.
2. The following are minimum standards. If noise coupling, EMI, or RFI become an issue in any installation, then measures shall be taken above and beyond those in IEEE 518 in order to eliminate the coupling or interference.
3. Voltage level and signal types are defined as follows:
 - a. Level 1 – Analog signals of less than 50 V and digital signals of less than 16 V.
 - b. Level 2 – Analog signals greater than 50 V and switching circuits.
 - c. Level 3 – Switching signals greater than 50 V, analog signals greater than 50 V, regulating signals of 50 V with currents less than 20 A, and AC feeders less than 20 A.
 - d. Level 4 - AC and DC busses of 0 V to 1000 V with currents between 20 A and 800 A
 - e. Level 4S - AC and DC busses greater than 1000 V and/or greater than 800 A
4. Separation Tables:

Spacing Within a Tray, Wireway or Enclosure (inches)					
Level	1	2	3	4	4S
1	0	1	6	26	26
2	1	0	6	18	26
3	6	6	0	6	12
4	26	18	6	0	0
4S	26	26	12	0	0

Tray to Conduit Spacing (inches)

Level	1	2	3	4	4S
1	0	1	4	18	18
2	1	0	4	12	18
3	4	4	0	0	8
4	18	12	0	0	0
4S	18	18	8	0	0

Conduit to Conduit Spacing (inches)					
Level	1	2	3	4	4S
1	0	1	3	12	12
2	1	0	3	9	12
3	3	3	0	0	6
4	12	9	0	0	0
4S	12	12	6	0	0

V. Wiring Standards:

1. Jumpering of control, signal, and common or return conductors shall not be allowed unless specifically called out in the contract drawings.
2. All PLC I/O modules have isolated inputs and outputs. Therefore, PLC I/O and field devices shall not have any signals jumpered or shared at the device or I/O module.
3. All field devices, including but not limited to switches, shall not share a conductor for any signals. For example, a pair of limit switches shall be wired with four conductors and not three.

W. Raceways for Fiber Optic Cables

8. Raceways containing fiber optic cables shall utilize long radius elbows and junction or pull boxes to maintain minimum bend radii for the cabling. The use of fittings (such as LB's) in lieu of long radius elbows, long radius field bends or oversized junction boxes shall not be permitted for installation of fiber optic cables.

END OF SECTION

SECTION 26 05 36 - WIRING DEVICES

PART 1 -- GENERAL

THE SUMMARY

The CONTRACTOR shall provide wiring devices, complete and operable, as indicated in accordance with the Contract Documents.

The requirements of Section 26 00 10– Electrical General Requirements apply to this Section.

Single Manufacturer

Like products shall be the end product of one manufacturer in order to achieve standardization of appearance, operation, maintenance, spare parts, and manufacturer's services.

CONTRACTOR SUBMITTALS

Furnish submittals in accordance with the requirements of Section 01 33 00– Submittal Procedures.

Shop Drawings

Submit complete catalog cuts of switches, receptacles, enclosures, covers and appurtenances, marked to clearly identify the proposed materials.

Submit documentation showing that the proposed materials comply with the requirements of NEC and U.L.

Submit documentation of the manufacturer's qualifications.

PART 2 -- PRODUCTS

GENERAL

Devices shall carry the U.L. label and shall be designed for use with stranded copper conductors.

Color

General purpose duplex receptacles and toggle switch handles shall be Brown everywhere except unless otherwise indicated.

Receptacles and switches shall be of specification grade and shall conform to NEMA WD-1, Federal Specifications W-C-596E and W-S-896E, respectively.

LIGHTING SWITCHES

Toggle switches shall be AC only type switch.

20A, 120/277V, Single, Double, 3-Way and 4-Way, Respectively

Leviton: 1221-2, 1222-2, 1223-2, 1224-2

Hubbell: HBL1221, HBL1222, HBL1223, HBL1224

Legrand: PS20AC1, PS20AC2, PS20AC3, PS20AC4
Or Equal

Hazardous Location Switches, shall be factory-sealed, 20A, 120-277VAC

Appleton: EDS
Crouse-Hinds: EDS
Hubbell Killark: FXS
Or Equal

GENERAL PURPOSE RECEPTACLES

Duplex receptacles shall be of the polarized 3-wire type for use with a 3-wire cord with grounded lead, and one designated stud shall be permanently grounded to the conduit system in accordance with NEC article 406.4.

Dry Areas

NEMA Configuration #5-20R: duplex receptacle rated 125V, 20A

Leviton: #5362
Hubbell: #HBL5362
Pass and Seymour: #5362A
Or Equal

NEMA Configuration #5-30R single receptacle rated 125V, 30A

Leviton: #5371
Hubbell: #HBL9308
Or Equal

Damp/Wet Areas

Receptacles for damp/wet locations shall be weather-resistant with extra duty, in-use listed covers in accordance with NEC Article 406.8.

GFCIs

Ground-fault circuit-interrupting receptacles (GFCIs) shall be installed at the indicated locations and as required by the NEC.

GFCIs shall be duplex receptacles, of specification grade, and tripping at 5 mA.

GFCI ratings shall be 125V, 20 amperes, NEMA WD-1, Configuration 5-20R, and capable of interrupting 5,000 amperes without damage.

GFCIs shall be weather resistant-listed in accordance with NEC Article 406.8.

Feed-through-type GFCIs serving standard receptacles will not be permitted.

Leviton: G5362-WT
Hubbel: GFR5362SG
Or Equal

ENCLOSURES AND COVERS

Surface-mounted switches and receptacles shall be housed in FS or FD-type weatherproof conduit fittings.

Switch and receptacle covers on surface-mounted boxes shall be constructed of die-cast copper-free aluminum.

Appleton: FSK

Crouse-Hinds: DS185 and WLRD-1

Hubbell Killark: FZ and FC

Or Equal

In finished areas, switch and receptacle covers shall be constructed of stainless steel.

Wet Locations

Receptacles in wet locations shall be provided with a hinged non-metallic Clear cover/enclosure marked "Suitable for Wet Locations when in use" and "UL Listed."

Provide a gasket between the enclosure and the mounting surface, and between the hinged cover and mounting plate/base.

Appleton: WCIU

Crouse-Hinds: TP74

Hubbell TayMac: Extra Duty

Or Equal

RECEPTACLE – SPECIAL PURPOSE

Special purpose receptacles shall be provided with the ratings and number of poles as indicated or required for the proposed purpose.

Provide a matching plug with cord-grip features with each special purpose receptacle.

NAMEPLATES

Provide nameplates or equivalent markings on the switch enclosures to indicate the ON and OFF positions of each switch.

ON and OFF for 3-way or 4-way switches will not be accepted.

Provide receptacles for special purposes with nameplates indicating their use.

Nameplates shall meet the requirements of Section 26 00 10 – Electrical General Requirements.

PART 3 -- EXECUTION

GENERAL

Perform WORK in accordance with the requirements of the NEC.

CONNECTION

Rigidly attach wiring devices in accordance with the NEC and as indicated, avoiding interference with other equipment.

Securely fasten nameplates using screws, bolts, or rivets centered under or on the device, unless otherwise indicated.

Receptacles indicated to be powered by uninterruptible power supplies (UPS) shall have a nameplate installed directly above the receptacle that reads:

(first line) "UPS-POWERED"

(second line) "NO TOOLS"

Nameplates shall meet the requirements of Section 26 00 10– Electrical General Requirements, and shall consist of a red plate with white letters a minimum of 1/4 inch tall.

GROUNDING

Devices, including switches and receptacles, shall be grounded in accordance with NEC, Article 250, and Section 26 05 26– Grounding and Bonding for Electrical System.

Switches and associated metal plates shall be grounded through the switch mounting yoke, outlet box, and raceway system.

FIELD TESTING

Provide checkout, field, and functional testing of wiring devices in accordance with Section 26 00 10 – Electrical General Requirements.

Test each receptacle for polarity and ground integrity, using a standard receptacle tester.

END OF SECTION

SECTION 26 05 43 - UNDERGROUND RACEWAY SYSTEMS

PART 1 -- GENERAL

1.01 THE SUMMARY

- A. The CONTRACTOR shall furnish and install as shown on the Contract Drawings, as specified or as directed, the Underground Raceway Systems, complete with shop drawings, and other appurtenances, and furnish all labor, supervision, materials, appurtenances, tools and ancillary services as required for a complete and operable installation in accordance with the requirements of the Contract Documents.
- B. Single Manufacturer: Like products shall be the product of one manufacturer in order to achieve standardization of appearance, operation, maintenance, and manufacturer's services.
- C. Manholes, pullboxes, and fittings that are dedicated to the underground raceway system shall comply with the requirements of this Section.

1.02 RELATED SECTIONS

Section 01 33 00 - Submittal Procedures.

Section 01 60 00 - Product Requirements.

Section 26 00 10 - Electrical General Requirements.

Section 26 05 33 - Electrical Raceway Systems

1.03 SUBMITTAL PROCEDURES

- A. Furnish submittals in accordance with the requirements of Section 01 33 00 – Submittal Procedures, and Section 26 00 10– Electrical General Requirements.
- B. Shop Drawings
 - 1. Submit complete catalog cuts of all raceways, fittings, pullboxes, and manholes, marked where applicable in order to show proposed materials and finishes.
- C. As-Built Drawings
 - 1. Prepare as-built drawings of encased concealed and exposed raceways, ducts, raceways, junction boxes, pull boxes, and electrical and instrumentation equipment.
 - 2. Show routings, burial depths, manhole and handhole locations and sizes, and where applicable, connections to drainage systems.
 - 3. Furnish the drawings to the ENGINEER in accordance with the requirements of Section 01 33 00 – Submittal Procedures

UNDERGROUND RACEWAY SYSTEMS

PART 2 -- PRODUCTS

2.01 GENERAL

- A. The ducts shall be sized as shown on the Contract Drawings.
- B. Raceways shall meet UL-651 and shall be so labeled.
- C. Assemble duct banks using non-magnetic saddles, spacers and separators. Separators are to be positioned to provide 3-inch minimum concrete separation between the outer surfaces of the ducts and shall allow concrete flow to be continuous throughout the length of the duct bank.

2.02 DUCTBANK SEALS

- A. Duct seals shall be installed at locations where ducts enter structures below grade. Duct seals shall be selected based on size and quantity of cables in each duct. Duct seals shall be **Raychem Rayflate Duct Sealing System (RDSS)**, **Polywater FST 25**, or approved equal.

2.03 MANHOLES AND PULLBOXES (HANDHOLES)

A. Frames and Covers

- 1. Provide traffic-type covers with an H-20 loading, except as otherwise indicated.
 - 2. Identify manhole and pull box covers as "ELECTRIC" by providing raised letters cast into the covers.
 - 3. Provide frost-proof and water-tight grey iron frames and covers with solid lids and inner lids, and with 28-inch clear openings.
 - 4. Bolt the covers and lids to cast-in-place steel frames using corrosion-resistant hardware.
 - 5. Factory-prime the frames.
 - 6. Provide covers constructed of cast-iron, and provide pick holes.
 - 7. Provide frames with a 1/2-inch drilled and tapped hole and lug in order to accommodate a No. 4/0 AWG bare stranded copper conductor connected to a ground rod and the ground conductor of power cables passing through the manhole.
 - 8. Manhole frames and covers shall be **Neenah Foundry No. NF-1755GT18** or equal.
- B. Equip manholes and pull boxes with pulling-in irons, opposite and below each ductway entrance.
 - C. Provide manholes and pull boxes with closed bottoms; open-bottom manholes and pull boxes will not be accepted.
 - D. Provide PVC duct bank conduits with end bells.

UNDERGROUND RACEWAY SYSTEMS

E. Brackets

1. Provide non-metallic, non-conductive brackets and stanchions in manholes as required for racking wiring through the manholes. Attach to manhole walls using stainless steel anchors and hardware.
2. Brackets and stanchions: **Underground Devices, Inc.**, or equal.

F. Precast Manholes and Pull boxes Manufacturer, or Equal

1. **Jensen Precast**
2. **Mack**
3. **Quikset**
4. **U.S. Precast**

2.04 DUCTBANKS

- A. Underground ducts shall be PVC Schedule 80 Electrical Raceways except ducts for instrumentation/ signal/ communication wiring, which shall be PVC coated rigid galvanized steel.
- B. Encase ducts in red-dyed concrete with steel reinforcing bars.
- C. Provide concrete with a 3,000-psi compressive strength conforming to the requirements of Section 03 31 50 – Cast-in-Place Concrete.
- D. Colorant
1. The concrete shall be dyed red throughout the ducts; surface treatment will not be accepted.
 2. Provide colorant consisting of an integral red-oxide coloring pigment in the proportion of 8 pounds per cubic yard of concrete.
 3. The costs, if any, of cleaning coloring pigment from the concrete delivery equipment and other related cleanings shall be considered as part of the WORK. Surface application of dye is not acceptable.

E. Ductbanks

1. Ductbanks shall contain a No. 4/0 bare stranded copper ground wire.
2. The ground wire shall be continuous through the ductbank and terminate at power distribution equipment and the grounding grid.

F. Identification Tape

1. Provide continuous lengths of underground warning tapes located 12 inches above and parallel to the ductbanks.

2. Provide tape consisting of 6-inch wide polyethylene film, imprinted with "CAUTION - ELECTRIC UTILITIES BELOW."
3. Provide tape that contains a non-ferrous metal foil conductor sandwiched in the tape for detection purposes.
4. Tapes shall be as manufactured by **Brady, Panduit**, or approved equal.

PART 3 -- EXECUTION

3.01 INSTALLATION

A. GENERAL

1. Underground raceways shall be installed essentially as indicated. Raceway systems shall be electrically and mechanically complete before conductors are installed. (CPP will install new electrical service conductors in the duct banks for the new services.) Bends and offsets shall be smooth and symmetrical and shall be accomplished with tools designed for this purpose. Factory elbows shall be utilized wherever possible.
2. Where raceway routings are indicated on plan views, the CONTRACTOR shall follow those routings to the extent possible. Adjustments shall be made based on field conditions and coordination with the OWNER.
3. Routings shall be adjusted to avoid obstructions. Perform potholing as required to identify potential obstructions, and repair damage to underground utilities because of the CONTRACTOR's work. Coordinate with all other trades prior to installation of raceways. Lack of such coordination shall not be justification for extra compensation, and removal and re-installation to resolve conflicts shall be at no extra cost to the OWNER.
4. Coordination with Other Trades
 - a. Coordinate with other trades prior to installation of raceways.
 - b. The lack of coordination shall not be justification for extra compensation.
 - c. Perform removal and re-installation to resolve conflicts as part of the WORK at no additional cost.

B. DUCTBANK

1. The underground concrete encased ductbank shall be installed in accordance with the criteria below:
 - a. Duct shall be assembled using high impact non-metallic spacers and saddles to provide conduits with vertical and horizontal separation. Separators are to be positioned to provide 3-inch minimum concrete separation between the outer surfaces of the ducts Plastic spacers shall be set every 5 feet. Anchor the duct array every 5 ft. in order to prevent movement during placement of concrete.

UNDERGROUND RACEWAY SYSTEMS

- b. The duct shall be laid on a grade line of at least 3 inches per 100 feet, sloping away from buildings. Duct shall be installed so that the top of the concrete envelope is a minimum of 18" below grade and a minimum of 24" below roadways. A warning tape shall be installed 12" above the full length of each duct bank.
 - c. Duct couplings shall be staggered a minimum of six (6) inches.
 - d. The bottom of trench shall be of select backfill or sand. The depth of the sand shall be a minimum of 3 inches
 - e. Each bore of the complete ductbank shall be cleaned by drawing through it a standard flexible mandrel one foot long and ¼ inch smaller than the nominal size of the duct through which the mandrel will be drawn. After passing of the mandrel, a wire brush and swab shall be drawn through. Existing unused ducts and ducts where cables are removed shall be swabbed and pull strings installed.
- 2. PVC duct entrances shall be grouted smooth; ducts shall be terminated with flush end bells. PVC coated rigid galvanized steel conduits shall be provided with insulated grounding style bushings which shall be connected to the No. 4/0 bare stranded copper ground wire.
 - 3. Ductbank penetration through walls of manholes or handholes and on building walls below grade shall be watertight.
 - 4. Changes in direction of the duct envelope by more than 10 degrees horizontally or vertically shall be accomplished using bends with a minimum radius 24 times the duct diameter.
 - 5. Make bends with sweeps of not less than 48-inch radius or 5 degree angle couplings.
 - 6. Identify each empty duct with a durable tag indicating the destination/origin of the duct. If destination/origin is within an enclosure, note inside the enclosure.
 - 7. Make a transition from PVC to PVC coated rigid steel (hazardous/classified or non-hazardous) or fiberglass (non-hazardous) conduit where duct banks enter structures or turn upward for continuation above grade.
 - 8. Sealing
 - a. Where an underground conduit enters a structure through a concrete roof or a membrane-waterproofed wall or floor, provide a Link-Seal or equal sealing device.
 - b. Use the sealing device with PVC coated rigid galvanized steel conduit.
 - c. Transition from PVC to PVC coated rigid galvanized steel conduit prior to building entry.

END OF SECTION

UNDERGROUND RACEWAY SYSTEMS

SECTION 26 05 50 – ELECTRIC HEAT TRACING

PART 1 -- GENERAL

1.01 SUMMARY

A. Section Includes

1. The supply of materials, design, fabrication, installation, testing, and commissioning of electrical heat tracing systems, engineered to suit application. Heat tracing for the surge tank and exposed piping shall be provided on the tank and exterior piping on the surge tank by the Contractor. All heat tracing components shall be supplied by the same manufacturer.
2. The heat tracing system shall include self-regulating electrical heat tracing cables, temperature controllers, contactors, field power connection kits, junction boxes, indicating lights, conduit, wires, grommet end termination kits, power connection kits, splice kits, NEMA 4X enclosed thermostats, piping insulation and jacket, installation tape, warning labels, and all necessary auxiliary equipment and controls.
3. The Contractor shall engage a qualified heat trace supplier for detailed design of the heat tracing system. Design to be submitted for review as Shop Drawings.
4. The heat tracing system supplier shall be completely responsible for the design of the system such that the entire system meets all aspects of this specification and the system functions in the environment where it will be installed. All parameters of the system shall be sized and as recommended by the supplier.
5. Piping insulation and jacket shall be supplied with all heat traced piping and shall be in conformance with Section 43 44 21.
6. All air release valve piping that will remain constantly wet and that is installed outdoors shall be heat traced. All pressure gauge piping installed outdoors shall be heat traced and insulated.
7. All the components of the heat tracing system shall be individually Underwriters Laboratory (UL) listed.

1.02 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

A. Reference Specifications

01 33 00	Submittal Procedures
01 78 36	Warranties
26 00 10	Electrical General Requirements
26 05 19	Wire and Cabling
43 44 21	Bladder Type Surge Tank

B. Reference Standards

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE Std 515	IEEE Standard for the Testing, Design, Installation, and Maintenance of Electrical Resistance Trace Heating for Industrial Applications
IEEE Std 515.1	IEEE Standard for the Testing, Design, Installation, and Maintenance of Electrical Resistance Trace Heating for Commercial Applications
NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)	
NFPA 497	Recommended Practice for the Classification of Flammable Liquids, Gases, or Vapors and of Hazardous (Classified) Locations for Electrical Installations in Chemical Process Areas UL 515 - Standard for Electrical Resistance Trace Heating for Commercial Applications
CSA GROUP (CSA)	
CSA C22.2 No. 130:16	Requirements for electrical resistance trace heating and heating device sets NFPA 499 – Recommended Practice for the Classification of Combustive Dusts and of Hazardous (Classified) Locations for Electrical Installations in Chemical Process Areas

C. Reference Codes

NATIONAL FIRE PROTECTION ASSOCIATION	
NFPA 70	National Electrical Code (NEC), latest edition

1.03 ACTION SUBMITTALS / INFORMATIONAL SUBMITTALS

A. Submit documents in accordance with Section 01 33 00 – Submittal Procedures and Section 26 00 10 – Electrical General Requirements.

B. Shop Drawings

1. Submit sufficient information to determine compliance with the Contract Documents and Drawings.
2. Provide a detailed design outlining the calculations that support the proposed product and installation methods for the designated application (piping materials and lengths, tank materials and sizes, insulation type and thickness, and other applicable requirements).
3. A complete heat loss calculation for each heater cable shall be provided.
4. Identify submittal data with the specific equipment tags and service descriptions to which they pertain. Submittal data shall be clearly marked to identify the specific model numbers, options, and features of equipment.
5. Manufacturer's data sheets or catalog pages clearly identifying the make, model, part number, equipment and component ratings, selected options, and selected accessories.
6. Descriptive bulletins, including accessories.
7. Wiring diagrams.

1.04 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data

1. Provide operating and maintenance data for materials and products as per the requirements outlined in Division 01 and Section 26 00 10 – Electrical General Requirements.
2. In addition, provide:
 - a. Complete description of operation together with general arrangement and detailed drawings, as-built wiring diagrams for power and control schematics, parts catalogues with complete list of repair and replacement parts, illustrating the connections and Manufacturer's identifying numbers for parts.
 - b. Completed test forms.
 - c. Manufacturer's published operation and maintenance procedures.

B. Warranty Documentation

1. Provide manufacturer's warranty documentation, in accordance with Section 01 78 36. Submit this information with the operating and maintenance data.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Storage and Handling Requirements

1. Store in a clean, dry space.
2. Maintain factory wrapping or provide an additional heavy canvas or heavy plastic cover to protect units from dirt, water, construction, debris, and traffic.

PART 2 -- PRODUCTS

2.01 PRODUCT TYPES

A. Performance / Design Criteria

1. The heat tracing system shall consist of the following materials and equipment to provide a complete heat traced system for freeze protection or process temperature maintenance:
 - a. NEMA 4X stainless steel power connection kits minimum. Provide NEMA 7 (explosion proof) or other suitably rated components to suit the application location and area classification. Refer to Drawings for area classification information.
 - b. Self-regulating electrical heat trace cables.
 - c. Heat trace smart controller with built-in ground fault protection with ambient sensing RTD for pipe and tank freeze protection.
 - d. 304L stainless steel pipe straps (to anchor termination kit(s) onto pipe).

- e. Glass tape (to fasten heat tracing cable on pipe).
 - f. Warning labels tagged "Electric Traced".
 - g. Lamacoid nameplates
2. Manufacturer List
- a. NVent Raychem Corporation
 - b. Chromalox (Emerson Electric Co.)
 - c. Thermon Manufacturing Company
 - d. Engineer Approved equivalent
3. Service Conditions
- a. All electrical heat tracing equipment shall be capable of satisfactory operation outdoors in an industrial facility, including hazardous classified areas as indicated on Drawings.
 - b. The Contractor shall certify and warrant that the design and the equipment is suitable to deliver rated performance and service life when subjected to the following conditions:
 - 1) The heat tracing system shall be capable of applying sufficient electrical heat to the outside of liquid or gas filled pipes, tanks, or equipment, to maintain 40 deg F and to prevent freezing during exposure to low ambient temperatures.
 - 2) The heat tracing system shall be capable of applying sufficient electrical heat to the outside of liquid or gas filled tanks to maintain process temperature as indicated.
 - 3) The heat tracing shall be suitable for installation in corrosive locations and hazardous areas as indicated on the Drawings.
4. Design Criteria
- a. The system design shall be based on the design parameters, system limits, isometric diagrams, P&IDs, layout drawings and/or line lists included with the Contract Documents and the following design parameters:
 - 1) Minimum start-up temperature shall be -20 deg F.
 - 2) Minimum ambient design temperature shall be -40 deg F.
 - 3) Maximum ambient design temperature shall be 104 deg F.
 - 4) Where exposed to wind, an appropriate wind speed shall be used based on site location.
 - 5) Heat loss safety factor of 25 percent minimum.

- b. Pipe length and tank sizes shall be verified in the field by the Contractor. Do not rely solely on the layout drawings, P&IDs, or piping isometrics included with the Contract Documents.
- c. Pipe material and size, insulation thickness and material, number of valves, flanges, and supports shall be as shown on the Contract Documents and confirmed by the Contractor.
- d. The final system design and equipment selection responsibility resides with the Contractor and shall be based on installed conditions, materials and reviewed shop drawings.

B. Materials

1. Electric Heat Tracing Cable

- a. Electric heat tracing cable shall be self-regulating type heater cable appropriate for the application.
- b. The general electrical heat tracing operating voltage shall be 120/240V, 1Ø 60Hz source.
- c. The heat tracing shall be capable of being overlapped on itself without causing localized hot spots or creating any hazards or possibility of burnout.
- d. Electric heat tracing for pipes shall account for all in-line components. All flanges, pumps, valves, devices, pipe supports, and appurtenances shall be traced with appropriate additional lengths of heater cable as required to account for additional heat loss from such components. Lengths, where shown on the Drawings, are estimated for preliminary loading calculations. Contractor shall confirm all lengths prior to ordering materials.

2. Temperature Sensing

- a. Freeze protection for piping shall be controlled as a group using an exterior mounted ambient sensing thermostat mounted to an appropriate JB, Raychem AMC-1A or equivalent. RTD to be mounted at least 10 ft from all windows, exhaust ports and other building openings that may affect the measured temperature.
- b. Ambient sensing RTD shall be designed for use on outdoor heat tracing system with an adjustable set point initially set at 41 deg F, in an NEMA 4X stainless steel enclosure; nVent type RTD-200 or equivalent.

3. Heat Trace Controller

- a. Use heat trace controllers designed for use on outdoor heat tracing system(s) complete with ground fault protection, adjustable set point(s), and enclosure rated NEMA 4X (or as otherwise required for hazardous locations); nVent DigiTrace 920 (for 2 points control) and DigiTrace 910 (for single point control) or equivalent.

- b. For grouped freeze protection, multiple heating cables may be operated in parallel from the same power circuit. Heating cables are to be grouped in a logical manner. No more than 5 lines may be grouped onto a single circuit. Circuit loading shall be limited to less than 30 amperes where possible, 60 amperes maximum.
 - c. Heat trace controllers shall include LED indicators for:
 - 1) Supply – shows that power is present.
 - 2) Heat – call for heat.
 - 3) Fault alarm.
 - d. Heat trace controller shall have Form C contacts for issuing, at a minimum, heat trace fault status signal to the plant control system for monitoring and alarming. Local alarm indicator is required in addition to remote alarm signal.
4. Power Connection Kit for Heat Tracing Cable
- a. All heater power connections between power cable and heat trace cable shall be made in a single-entry power connection kit that is appropriately rated for area classification.
 - b. End seal kits shall be provided for each heat tracing cable and tee connection kits. Provide lighted end kits.
 - c. Power and lighted end kits shall be mounted in visible and accessible locations.

PART 3 -- EXECUTION

3.01 INSTALLATION

- A. Provide all labor and materials and make all necessary arrangements, except as specifically noted herein, to provide a fully working system.
- B. The heat trace system components shall be installed as per the manufacturer's instructions and recommendations and in accordance with the applicable codes and standards.
- C. Provide full integration of the heat tracing system with the power and controls system, including all necessary conduit, wiring, terminations, and connections.
- D. The heat trace equipment and materials shall be installed without trapping any piping system components and shall allow for removal of piping system components without cutting or damaging the heat trace materials.
- E. Install the heat tracing cable so that it can be continuously covered by the piping insulation. Do not install the heat tracing cable in such a manner that there are exposed sections outside the insulation.

- F. Attach the heat tracing cable to the pipes at spacings as recommended by the manufacturer with pressure sensitive glass cloth tape having thermosetting electrical grade adhesive. Heat tracing cable shall be self-supporting and in such a manner that pipe insulation can be installed and removed without the need to adjust the cable. Do not use vinyl electrical tape and avoid spiraling.
- G. Provide junction boxes for power supplies to the various heat tracing cables. The junction box shall be sized and rated in accordance with the applicable codes.
- H. Terminate the heat tracing cable at the power connection kit enclosure, mounted outside of pipe insulation and jacketing.
- I. Install and terminate end seal kit mounted outside of pipe insulation and jacketing.
- J. Install "Electric Traced" labels at either end and at intervals not greater than 20 ft and more at key access areas and at traced devices such as valves. Labels shall be nVENT ETL or equivalent.
- K. Supply and install nameplates on the front of each power connection kit enclosure at both ends of the heat tracing system in accordance with Section 26 00 10 – Electrical General Requirements.
- L. Power Supply to Heat Tracing Cable
 - 1. Wiring and connectors in accordance with Section 26 05 19 – Wire and Cabling. Cables and all conductors shall be identified on both ends with markers in accordance with Section 26 00 10 – Electrical General Requirements.
 - 2. The branch circuit shall be dedicated to the heat trace system. Branch circuit breaker shall be GFEP type, size shall not exceed 30 amperes where possible (60 amperes where required) and shall be sized based on the total inrush current of the self-regulating cable.
 - 3. The maximum voltage drop shall not exceed 3 percent.

3.02 TESTING

- A. Complete verification and testing in accordance with Section 26 01 26.
- B. All heat tracing cables shall be meggered with a minimum 1000 volts DC. The following separate field megger readings shall be taken on each heat tracing cable:
 - 1. Heater cable shall be meggered when received at jobsite before installation.
 - 2. Heater cable shall be meggered after installation but prior to insulation being applied.
 - 3. Heater cable shall be meggered after insulation has been installed.
 - 4. All 3 of the above field megger readings shall be at least one megohm. Contractor shall replace and re-megger any heat tracing cables not meeting at least 1 megohm.
- C. Field megger tests shall be recorded for each heater cable and certified reports shall be included with close-out submittal.

- D. The Owner and Engineer shall be permitted to inspect the heat tracing cable installation prior to application of piping or tank insulation systems. Notify The Owner and Engineer at least 14 days prior to the date of the installation of insulation.

END OF SECTION

SECTION 26 05 73 – PROTECTIVE DEVICE STUDIES

PART 1 -- GENERAL

1.01 THE SUMMARY

- A. The CONTRACTOR shall perform the indicated short circuit and protective device studies for the electrical power system in accordance with the Contract Documents.
- B. The WORK of this Section shall include protection studies for motors with solid state overload and overcurrent protection devices.
- C. It is the responsibility of the CONTRACTOR to obtain the information required from the electric utility and appropriate vendors.

1.02 QUALIFICATIONS

- A. Short circuit studies, protective device evaluation studies, arc-flash hazard analysis studies, and protective device coordination studies shall be performed by a manufacturer who has been regularly engaged in short circuit and protective device coordination services for a period of at least 15 years.
- B. The indicated studies shall be signed by the professional electrical engineer, registered in the State of OHIO, responsible for the studies.
- C. The studies shall utilize computer programs with proven reliability and accuracy for performing 3-phase fault-duty calculations.

1.03 SUBMITTAL PROCEDURES

- A. The indicated studies shall be submitted and approved by the ENGINEER prior to final approval of the distribution equipment Shop Drawings and release of equipment for manufacture.
- B. An initial short circuit study shall be submitted and reviewed before the ENGINEER will approve the Shop Drawings for medium-voltage switchgear, transformers, or 480-volt distribution equipment.
- C. Submit an initial protective device coordination study shall be submitted with 90 days after the approval of the initial short circuit study.
- D. The short circuit, arc-flash hazard analysis, and protective device coordination studies shall be updated prior to Project Substantial Completion; utilize characteristics of as-installed equipment and materials.
- E. The adequacy of the equipment "withstand" and interruption ratings shall be approved by the ENGINEER.

1.04 MANUFACTURERS' SERVICES

- A. The low-voltage switchgear manufacturer shall furnish the services of a qualified field engineer and necessary tools and equipment in order to test, calibrate, and adjust the protective relays and circuit breaker trip devices as recommended in the power system coordination study.
- B. The motor control center manufacturer shall furnish the services of a qualified field engineer to calibrate the MCPs as recommended in the power system study.

PART 2 -- PRODUCTS (NOT USED)

PART 3 -- EXECUTION

3.01 GENERAL

- A. The studies shall include development of single-line and impedance diagrams of the power system.
- B. The diagrams shall identify components considered in the study and the ratings of power devices, including transformers, circuit breakers, relays, fuses, busses, and cables.
- C. The resistances and reactances of cables shall be identified in the impedance diagram.
- D. The studies shall contain written data from the electric utility company regarding maximum available short circuit current, voltage, and X/R ratio of the utility power system.
- E. The studies shall include every protective device and feeder included or modified within the WORK.
- F. The first upstream overcurrent device outside the WORK shall be used as a fixed reference.
- G. The studies shall include all portions of the electrical distribution system for normal and standby power sources down to and including the 480-volt distribution system.

3.02 SHORT CIRCUIT STUDY

- A. The short circuit study shall be performed with the aid of a digital computer program, and shall be in accordance with the following Standards:

ANSI/IEEE 141	Recommended Practice for Electrical Power Distribution for Industrial Plants
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ANSI/IEEE 242	Recommended Practice for Protection, and Coordination of Industrial, and Commercial Power Systems
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ANSI/IEEE C 37.010 Application Guide for AC High-Voltage Circuit Breakers
Rated on a Symmetrical Current Basis

ANSI/IEEE C 37.13 Low-Voltage AC Power Circuit Breakers Used in Enclosures

3.03 PROTECTIVE DEVICE EVALUATION STUDY

A protective device evaluation study shall be performed in order to determine the adequacy of circuit breakers, molded case switches, and fuses.

Any problem areas or inadequacies in the equipment due to prospective short-circuit currents shall be promptly brought to the attention of the ENGINEER.

Do not utilize series-rated circuit breakers to meet short circuit requirements for this project.

Devices shall be fully rated to withstand available fault currents.

3.04 PROTECTIVE DEVICE EVALUATION STUDY

- A. A protective device coordination study shall be performed in order to develop the necessary calculations to select power fuse ratings, protective relay characteristics and settings, ratios and characteristics of associated current transformers, and low-voltage breaker trip characteristics and settings.
- B. Any problem areas or inadequacies in the equipment due to prospective short-circuit currents shall be promptly brought to the ENGINEER's attention.

3.05 TIME/CURRENT COORDINATION CURVES

- A. As a minimum, the time/current coordination curves for the power distribution system shall include the following items plotted on 5-cycle log-log graph paper:
 - 1. time/current curves for each protective relay, circuit breaker, or fuse demonstrating graphically that the settings will provide protection and selectivity within industry standards
 - 2. Each curve shall be identified, and tap and time dial settings shall be specified.
 - 3. Provide individual curves for each feeder unless identical to others.
 - 4. Selectivity
 - a. Time/current curves for each device shall be positioned to provide the maximum selectivity to minimize system disturbances during fault clearing.

PROTECTIVE DEVICE STUDIES

- b. Where selectivity cannot be achieved, the ENGINEER shall be notified as to the cause.
 - c. Recommendations shall be included for alternate methods that would improve selectivity.
5. time/current curves and points for cable and equipment damage.
 6. circuit interrupting device operating and interrupting times
 7. Indicate maximum fault values on the graph.
 8. sketch of bus and breaker arrangement
 9. magnetizing inrush points of transformers
 10. thermal limits of dry-type and liquid-insulated transformers (ANSI damage curve)
 11. Every restriction of the ANSI and National Electrical Code shall be followed, and proper coordination intervals and separation of characteristics curves shall be maintained.

3.06 ARC FLASH STUDY

- A. An arc flash study shall be performed with the aid of a digital computer program in order to determine the "Arc Flash Protection Boundary" and "Personal Protective Equipment" (PPE) levels for applicable electrical distribution equipment, stand-alone disconnects, starters, and VFDs in the power distribution system.
- B. The arc flash study shall be performed in conjunction with short circuit calculations and protective device coordination.
- C. The arc flash study shall be in accordance with the latest version of the following Standards:
 1. NFPA 70E Standard for Electrical Safety Requirements for Employee Workplaces
 2. IEEE 1584 IEEE guide for performing Arc Flash Hazard Calculations
 3. OSHA (29 CFR PART 1910) Occupational Safety and Health Standards for General Industry
 4. ANSI Z535.4 Product Safety Signs and Labels
- D. The recommended values for the "Arc Flash Protection Boundary" and PPE levels, based on the arc flash study results, shall be tabulated in the study.
- E. Labeling
 1. The digital computer program shall provide the "Arc Flash Protection Boundary" and PPE values in a format that can be directly printed on to labels.

PROTECTIVE DEVICE STUDIES

2. The CONTRACTOR shall provide these labels in accordance with Section 26 00 10– Electrical General Requirements.

3.07 FINAL SUMMARY REPORT

- A. Summarize the results of the indicated power system studies in a final report.
- B. The report shall include the following items:
 1. single-line diagram
 2. impedance diagram
 3. tabulation of all protective devices identified on the single line diagram
 4. time/current coordination curves
 5. specific recommendations, if any
 6. test instrumentation, condition, and connections, as applicable, for each study
 7. computerized fault current calculations
 8. any suggested changes to the protection scheme or equipment selection that will result in improved system reliability and safety
 9. recommendations to minimize the arc flash energy
- C. The report shall include information concerning the computer program used for the study, as well as a general discussion of the procedure, items, and data considered in the preparation of the study.

3.08 PROTECTIVE DEVICE TESTING, CALIBRATION, AND ADJUSTMENT

- A. Test, calibrate, and adjust the protective relays and circuit breaker trip devices in accordance with the recommendations in the power system coordination study.
- B. Calibrate the MCPs as in accordance with the recommendations in the power system study.
- C. Adjustments shall be made prior to energizing any electrical equipment.

END OF SECTION

SECTION 26 11 10 – LOW-VOLTAGE SWITCHGEAR

PART 1 -- GENERAL

1.1 THE SUMMARY

- A. The GENERATOR SUPPLIER shall furnish a front-accessible low-voltage metal-enclosed switchgear assembly, as specified herein and in accordance with the Contract Documents.
- B. Unit Responsibility: A single generator manufacturer shall be responsible for furnishing the low-voltage switchgear, to the CONTRACTOR; and for coordination of design, assembly, testing, and installation of the generator system. The low-voltage switchgear and generator shall be provided as a coordinated package by the GENERATOR SUPPLIER. The low-voltage switchgear shall be produced and assembled by the manufacturer at a facility owned or operated by the manufacturer and under the direct supervision and control of the manufacturer. The CONTRACTOR will furnish and/or coordinate all components and accessories as necessary to place the equipment in operation in conformance with the specified performance, features and functions described implicitly herein or implied.
- C. The requirements of Division 1 and Section 26 00 10 – Electrical General Requirements, apply to the WORK of this Section.
- D. Furnish a Remote Operating Panel (ROP) for operation of circuit breakers as called for herein, on the Contract Drawings and per Section 26 05 15 – Industrial Control Panels and Miscellaneous Devices.
- E. UL Label
 - 1. The switchgear assembly shall bear a UL label.
 - 2. Furnish certified copies of design test reports demonstrating compliance with UL standards.

1.2 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

- A. Reference Codes
 - 1. The indicated WORK shall conform to or exceed the applicable requirements of the National Electrical Code (NEC), provided that where a local code or ordinance is in conflict with the NEC, the provisions of the local code or ordinance shall take precedence.
 - 2. Additional requirements are indicated in Section 26 00 10 – Electrical General Requirements.
- B. Commercial Standards
 - ANSI/NFPA 70 National Electrical Code
 - UL 1558 Metal-Enclosed Low-Voltage Power Circuit Breaker Switchgear

UL 1066	Low-voltage power circuit breakers
IEEE C37.17	Trip Systems for Low-Voltage AC and General Purpose DC Circuit Breakers
IEEE C37.20.1	Metal-Enclosed Low-Voltage Power Circuit Breaker Switchgear
IEEE/ANSI C37.13	Low-voltage power circuit breakers
IEEE/ANSI C37.17	Trip devices

C. Related Sections

1. Section 01 33 17 – Structural Design, Support and Anchorage
2. Section 01 61 10 – Equipment Pre-Procurement – General
3. Section 26 32 13 – Standby Power Generation
4. Section 26 43 00 – Surge Protection Devices (SPD)

1.3 SUPPLIER SUBMITTALS

- A. Submittals shall conform to the requirements of Section 26 00 10 – Electrical General Requirements and Section 01 33 00 – Submittal Procedures.
- B. The following information shall be submitted to the ENGINEER:
 1. Master drawing index
 2. Front view and plan view of the assembly
 3. Three-line diagram
 4. Schematic diagram
 5. Nameplate schedule
 6. Component list
 7. Conduit space locations within the assembly
 8. Assembly ratings including:
 - a. Short-circuit rating
 - b. Voltage
 - c. Continuous current rating
 9. Major component ratings including:
 - a. Voltage
 - b. Continuous current rating

c. Interrupting ratings

10. Cable terminal sizes

11. Product data sheets

Where applicable, the following additional information shall be submitted to the ENGINEER:

12. Busway connection

13. Composite front view and plan view of close-coupled assemblies

14. Key interlock scheme drawing and sequence of operations

15. Automatic transfer scheme sequence of operation

16. Mimic bus size and color

C. The following information shall be submitted for record purposes:

1. Final as-built drawings and information for items listed above, and shall incorporate all changes made during the manufacturing process

2. Wiring diagrams

3. Certified production test reports

4. Installation information

5. Seismic certification as specified

D. The final (as-built) drawings shall include the same drawings as the construction drawings and shall incorporate all changes made during the manufacturing process.

1.4 CERTIFICATIONS

1. Certified factory design test report

2. Design certification of the anchoring systems for seismic requirements in conformance with the requirements of Section 01 33 17 – Structural Design, Support and Anchorage and Section 26 00 10 – Electrical General Requirements, for the indicated equipment.

1.5 QUALIFICATIONS

A. The manufacturer of the assembly shall be the manufacturer of the major components within the assembly. Note that the GENERATOR SUPPLIER is not required to also be the low-voltage switchgear manufacturer.

B. For the equipment specified herein, the manufacturer shall be ISO 9001 or 9002 certified.

C. The manufacturer of this equipment shall have produced similar electrical equipment for a minimum period of five (5) years. When requested by the ENGINEER, an acceptable

list of installations with similar equipment shall be provided demonstrating compliance with this requirement.

1.6 SPARE PARTS, TOOLS AND MAINTENANCE DATA

A. Spare parts

1. Spare parts data, listing source of recommended replacement parts and supplies.

B. Recommended maintenance procedures and intervals.

C. Complete list of tools for the operation and maintenance of the unit.

D. Installation, maintenance, troubleshooting and operating instructions for all components.

E. As-built record drawings.

1.7 QUALITY ASSURANCE

A. Storage

1. Factory wrapping shall be provided in order to protect units from dirt, water, construction debris, and traffic during delivery.

2. The CONTRACTOR will provide a storage space that is temperature and humidity controlled.

B. Factory Tests:

1. Submit a certification of design tests previously conducted on one air-break circuit breaker and switchgear assembly of each rating similar to that indicated.

2. The design testing program shall conform to the requirements of IEEE C37.20.1 and shall include the following tests:

- a. Dielectric

- b. Continuous current

- c. Withstand

- d. Endurance

3. The low-voltage switchgear section, including any transition section, shall be completely assembled, wired, adjusted, and tested at the factory.

4. After assembly, the complete switchgear shall be tested for operation under simulated service conditions in order to assure the accuracy of the wiring and the functionality of the equipment. The switchgear manufacturer shall arrange for virtual witness testing of the generator transfer/retransfer control schemes with the ENGINEER and OWNER to demonstrate proper operation of the transfer schemes under simulated conditions.

5. Production Testing

- a. Production tests shall be conducted on each low-voltage switchgear assembly, and a certification of each test shall be submitted.
- b. The production testing program shall conform to the requirements of IEEE C37.20.1 and other related ANSI standards, as well as the applicable standards of IEEE and of NEMA SG-5.
- c. Production testing shall include the following tests:
 - 1) Contact resistance measurement of all 3 phases
 - 2) Operation of each electrically-operated breaker with the control power supply voltage adjusted to the limits indicated
 - 3) Check of safety interlocks
 - 4) Interchangeability of circuit breakers of the same ratings in various compartments
- C. The switchgear shall be designed for continuous duty service in the environmental conditions indicated in Section 26 00 10 – Electrical General Requirements.

1.8 MAINTENANCE AND GUARANTEE

- A. GENERATOR SUPPLIER shall guarantee that the equipment shall meet the requirements herein and Section 26 00 10 - Electrical General Requirements.
- B. Equipment operation and maintenance manuals shall be provided with each assembly shipped and shall include instruction leaflets and instruction bulletins for the complete assembly and each major component.
- C. See Section 01 61 10 – Equipment Pre-Procurement – General for additional information regarding equipment warranty.

PART 2 -- PRODUCTS

2.1 CIRCUIT BREAKER/SWITCHGEAR MANUFACTURERS

- 1. Circuit Breaker Manufacturers
 - a. Eaton, Front Access Magnum DS
 - b. Square D, Power-Zone-4 Front Access
- 2. Switchgear Manufacturers: Note that the manufacturers listed above are for the low-voltage switchgear circuit breakers. The switchgear shall be assembled using one of the above-named circuit breaker manufacturers. This switchgear must be designed for front-access only. The switchgear lineup shall be manufactured and assembled by:
 - a. APT (Advanced Power Technologies), or
 - b. Russelectric

The listing of specific manufacturers above does not imply acceptance of their products that do not meet the specified ratings, features and functions. Manufacturers listed above are not relieved from meeting these specifications in their entirety. The switchgear manufacturer shall select the circuit breaker manufacturer based on availability of equipment to minimize the time required to deliver the switchgear to the site.

2.2 DESIGN REQUIREMENTS

- A. The switchgear shall be suitable for indoor service configured as indicated on the Contract Drawings, and shall be fully integrated, and meeting the requirements of NEMA.
- B. The phase-sequence of the assembled 3-phase buses, and primary conductors shall be A, B, C starting from front-to-back, top-to-bottom, or left-to-right as viewed from the front of the switchgear.
- C. Switchgear assemblies shall include the following equipment:
 - 1. Switchgear lineups shall include air breakers, metering, and associated standard and optional accessories as indicated.
 - 2. BIL rating shall be NEMA standard for the service.
 - 3. The switchgear shall be front-accessible.

2.3 RATINGS

- A. The entire assembly shall be suitable for 600 VAC maximum service

480V SWITCHGEAR (SWGR-1) FEATURES	
Rating	1600A, 480V, 3 ϕ , 3W, 60Hz
Structure	Enclosed, free-standing assembly, front-accessible
Enclosure	NEMA 1
Continuous main bus current	1600A
Short-circuit withstand	65kAIC
Bus bracing Short-circuit withstand	Not less than 65kAIC

- B. All circuit breakers shall have a minimum symmetrical interrupting capacity of 65 kAIC. To ensure a fully selective system, all circuit breakers shall have 30-cycle short-time withstand ratings equal to their symmetrical interrupting ratings, regardless of whether equipped with instantaneous trip protection or not.

2.4 CONSTRUCTION FEATURES

- A. The switchgear shall consist of the required number of vertical sections bolted together to form a rigid assembly. The sides shall be covered with removable bolt-on covers. All edges of front covers or hinged front panels shall be formed. Provide ventilators located on the top of the switchgear over the breaker and bus compartments to ensure adequate ventilation within the enclosure. Cable compartment access shall be provided by front covers fabricated in two (2) pieces for ease of handling and mounted using hinged front doors, complete with keylockable hardware.
- B. The sides shall be covered with removable bolt-on covers. All edges of front covers or hinged front panels shall be formed. Provide ventilators located on the top of the switchgear over the breaker and bus compartments to ensure adequate ventilation within the enclosure.
- C. The assembly shall be provided with adequate lifting means and shall be capable of being moved into installation position and bolted directly to the floor without the required use of floor sills providing the floor is level to 1/8 inch per three feet distance in any direction. Provisions shall be made for jacking of shipping groups, for removal of skids or insertion of equipment rollers. Base of assembly shall be suitable for rolling directly on pipes without skids. The base shall be equipped with slots in the base frame members to accommodate the use of pry bars for moving the equipment to its final position. Compartment doors shall be hinged flanged dead-front panels.
- D. Each vertical steel unit forming part of the switchgear line-up shall be a self-contained housing having one or more individual breaker or instrument compartments and a centralized bus compartment. A front cable access compartment shall be provided as part of, or beside each breaker structure. Each individual circuit breaker compartment shall be segregated from adjacent compartments and sections by means of steel barriers to the maximum extent possible. It shall be equipped with drawout rails and primary and secondary disconnecting contacts. Removable hinge pins shall be provided on the breaker compartment door hinges. Current transformers for feeder instrumentation, where shown on the plans, shall be located within the appropriate breaker cells and be front accessible, removable, and provided with shorting terminal blocks in the front wireway. Circuit breaker doors shall not be ventilated.
- E. The circuit breaker door design shall be such that the following functions may be performed without the need to open the circuit breaker door: lever circuit breaker between positions, operate manual charging system, close and open circuit breaker, examine and adjust trip unit, and read circuit breaker rating nameplate.
- F. The removable power circuit breaker element shall be equipped with disconnecting contacts and interlocks for drawout application. It shall have four positions, "connected," "test," "disconnected" and "removed." The breaker drawout element shall contain a worm gear levering "in" and "out" mechanism with removable lever crank. Levering shall be accomplished via the use of conventional tools. Mechanical interlocking shall be provided so that the breaker is in the tripped position before levering "in" or "out" of the cell. The breaker cell shall include an optional provision for key locking open to prevent manual or electric closing. Padlocking shall provide for securing the breaker in the connected, test, or disconnected position by preventing levering. Breaker shall be ready to accept connection of remote racking device without modification of breaker, cell or door.

- G. An insulating flash shield shall be mounted above each circuit breaker to prevent flashover from the arc chutes to ground.
- H. Provide a glass polyester full height and depth barrier between adjacent vertical structures in the bus compartment with appropriate slots for main bus.
- I. The switchgear shall be suitable for use as service entrance equipment and be labeled in accordance with UL requirements.
- J. Provide a barrier between the cable compartment and the main bus to protect against inadvertent contact with main or vertical bus bars. Barrier shall be ventilated grounded steel.
- K. Provide a safety shutter in the cell when the circuit breaker is withdrawn, which automatically covers the line and load stabs and protects against incidental contact. Provide padlockable breaker door to prevent access to shutter when breaker is removed from cell.
- L. Provide a metal barrier full height and depth between adjacent vertical structures in the cable compartment.
- M. No rear access shall be required for power cable terminations, connections, or inspection. Only front access shall be available for equipment installation, and the switchgear may be installed against a back wall.
- N. Provide a 4" diameter polymer lens infrared (IR) scanning window for each set of circuit breaker terminations, mounted on cable compartment door.

2.5 BUS

- 1. Buses shall be of high-conductivity tin-plated copper, sized for the rated continuous and momentary currents within allowable temperature rise, and shall not be tapered.
- 2. Buses shall be braced to withstand a short circuit current of 65,000 amperes symmetrical.
- 3. Bus Joints
 - a. Bus joints shall be welded, brazed, or bolted. The bus bar shall be bolted where horizontal and vertical buses are joined.
 - b. Bolted joints for buses, interconnections, disconnecting devices, and external connections to the equipment shall be of copper with tin plated torqued contacts.
 - c. Bolted joints shall have Belleville-type washers.
 - d. Bolts and associated hardware shall be corrosion-resistant.
- 4. Insulating Barriers
 - a. Insulating barriers shall be provided where primary buses pass from one compartment to another.

- b. The main and riser bus shall be fully isolated from the circuit breaker and instrument and auxiliary compartments.
 - c. Solid vertical insulating barriers shall be provided in the section between the cable and bus compartments.
 - d. Insulated bus supports shall be of flame-retardant polyester glass, designed and tested to withstand the mechanical stress produced by fault currents as required.
5. Isolation
- a. Provide isolating barriers between the incoming line and main bus systems in order to prevent fault communication.
 - b. Provide insulating sleeves in the feeder run-back conductor in the bus compartment in order to prevent fault communication in that area.
6. Ground Bus
- a. Provide a tin-plated copper ground bus extending the entire length of the switchgear assembly and incoming line compartment.
 - b. The ground bus short-time withstand rating shall meet that of the largest circuit breaker within the assembly. The ground bus plating shall match main bus plating.
 - c. The ground bus shall be provided with clamp type terminal lugs, adjustable between 4/0 AWG and 500 MCM at each end for external cable connections. Lugs shall be provided in the incoming line section for connection of the main grounding conductor and at each end of the ground bus for connection to system ground. Additional lugs for connection of other grounding conductors shall be provided as indicated on the drawings.
 - d. All metal parts of the structure shall be effectively connected to the ground bus.
 - e. The ground bus shall be of rectangular cross section, not less than 1/4-inch by 1-1/2 inches.

2.6 Space Heaters

- 1. Space heaters shall have mechanical guards and be provided in each vertical section.
- 2. Heaters shall be of the low-temperature type, rated (nominally) at 120 volts, and with a single-pole circuit breaker.
- 3. The heaters shall be sized to keep the air inside the enclosure above the dew point.
- 4. Heaters shall be thermostatically controlled.
- 5. Heaters shall be monitored for operation, and shall indicate an alarm via a pilot light on the front of the switchgear.

B. Cable Compartments

1. Isolated from the bus compartments and have ample space for cable entry from above or below, and shall be accessible from the front only.

C. Low-Voltage Circuit Breaker Compartments

1. Each low-voltage circuit breaker compartment shall have a drawout mechanism consisting of an integral racking device in order to lock the removable element in the connected position and to overcome the mechanical resistance of making and breaking the contacts of the disconnecting devices.
2. Positive mechanical interlocks of rugged design shall prevent the breaker from being racked in or out unless the breaker is tripped and shall prevent the breaker from being closed while it is being racked in or out.
3. The breaker drawout mechanism shall be of a design that permits the breaker to be racked from the connected to the test and disconnected positions with the door closed or a metal breaker cover in place.
4. Each compartment shall have protection shutters to automatically cover primary line and secondary load studs when the circuit breaker is withdrawn.
5. Provide a manual release in order to hold the breaker in the TEST and DISCONNECTED positions.
1. Provide a limit stop in the fully withdrawn position, and in this position, there shall be provisions for easy maintenance, inspection or removal.

D. External Connections

1. Primary cable compartments shall include connector and cable supports.
2. Ground sensing current transformers, if required, shall be mounted in the respective cable compartments or at the breakers cell.

E. Wiring/Terminations

1. Provide control wiring to auxiliary relays and devices indicated to be furnished with the equipment.
2. Small wiring, necessary fuse blocks and terminal blocks within the switchgear shall be furnished as required. Control components mounted within the assembly shall be suitably marked for identification corresponding to the appropriate designations on manufacturer's wiring diagrams.
3. Provide a front accessible, isolated vertical wireway for routing of factory and field wiring. Factory provisions shall be made for securing field wiring without the need for adhesive wire anchors.
4. Front access to all circuit breaker secondary connection points shall be provided for ease of troubleshooting and connection to external field connections without the need of removing the circuit breaker for access.
5. Control wiring shall be brought to identified terminal blocks.

6. Connections made on terminal blocks and on internal devices shall be by means of locking-spade type, pre-insulated terminals.
7. All groups of control wires leaving the switchgear shall be provided with terminal blocks with suitable numbering strips and provisions for #10 AWG field connections.
8. Terminal blocks for external control connections shall be of the 600 V, barrier type, having a minimum rating of 20 amperes with marker strips identifying internal and external wiring.
9. Terminal blocks shall be sized to have at least 20 percent unused spare connections after completion of wiring.
10. One 4-pole block shall be used for each current transformer set.
11. Wiring identified for connection to the plant SCADA system shall be terminated to terminal blocks and a nameplate shall be installed stating: "CONNECTIONS DEDICATED FOR SCADA". Terminal connections to remote devices or sources shall be front accessible via doors above each circuit breaker.
12. Control and secondary wiring shall be 600 volt flame-retardant switchboard type SIS, minimum size No. 14 AWG, stranded tinned copper. Wire bundles shall be secured with nylon ties and anchored to the assembly with the use of pre-punched wire lances or nylon non-adhesive anchors. All current transformer secondary leads shall first be connected to conveniently accessible shorting terminal blocks before connecting to any other device. Shorting screws with provisions for storage shall be provided.
13. Terminal connections to remote devices or sources shall be front accessible via doors above each circuit breaker.
14. Hinge wiring shall be extra-flexible stranding.
15. Each control wire shall be marked to the origin zone/wire name/destination zone over the entire length of the wire using a cured ink process. Provide additional printed heat-shrink wire markers at each end of all control wiring.
16. NEMA 2-hole compression type lugs shall be provided for all line and load terminations suitable for copper cable rated for 75°C of the size indicated on the drawings.

2.7 COMPONENTS

A. CIRCUIT BREAKERS

1. All protective devices shall be low-voltage power circuit breakers. All breakers shall be UL and CSA approved listed for application in their intended enclosures for 100% of their continuous ampere rating.
2. Circuit breakers shall have 30 cycle withstand ratings.
3. Breakers shall be provided in drawout configuration. All breaker cell sizes shall have a common height and depth. Breaker frames of the same size shall be fully interchangeable.

4. Power circuit breakers shall utilize a two-step stored-energy mechanism to charge the closing springs. The closing of the breaker contacts shall automatically charge the opening springs to ensure quick-break operation. Slow closing speed shall not be required to properly maintain the breaker contacts.
5. All circuit breakers shall be electrically operated (EO) with 120 VAC motor operators. The charging time of the motor shall not exceed 6 seconds.
6. To facilitate lifting, the power circuit breaker shall have integral handles on the side of the breaker.
7. The power circuit breaker shall have a closing time of not more than 3 cycles.
8. The primary contacts shall have an easily accessible wear indicator to indicate contact erosion.
9. The power circuit breaker shall have three windows in the front cover to clearly indicate any electrical accessories that are mounted in the breaker. The accessory shall have a label that will indicate its function and voltage. The accessories shall be plug and lock type and UL listed for easy field installation. They shall be modular in design and shall be common to all frame sizes and ratings.
10. The breaker control interface shall have color-coded visual indicators to indicate contact open or closed positions, as well as mechanism charged and discharged positions. Manual control pushbuttons on the breaker face shall be provided for opening and closing the breaker. The breaker flag will read "Closed" if the contacts are welded and the breaker is tripped or opened.
11. The current sensors shall have a back cover window that will permit viewing the sensor rating on the back of the breaker. A rating plug will offer indication of the rating on the front of the trip unit. The current sensor and rating plug shall be of the same current rating.
12. A position indicator shall be located on the faceplate of the breaker. This indicator shall provide color indication of the breaker position in the cell. These positions shall be Connect (Red), Test (Yellow), and Disconnect (Green). The levering door shall be interlocked so that when the breaker is in the closed position, the breaker levering-in door shall not open.
13. Provide bell alarm and form "C" auxiliary contacts wired to an identified terminal strip.
14. Charging or energy storage springs shall be capable of being manually charged from an operating handle.
15. Electrically operated circuit breakers shall also be equipped with electrically trip-free operating mechanisms.
16. Each circuit breaker and provision for future circuit breaker shall include opened (green), tripped (amber), closed (red), and maintenance mode (blue) pilot lights, breaker control switch, maintenance mode switch all mounted on the Remote Operating Panel (ROP) to be provided by the switchgear manufacturer. The switchgear shall have terminals provided in a single cubicle for connection to the ROP. Interconnection wiring between the switchgear and the ROP will be provided by the CONTRACTOR.

17. Circuit breakers shall be capable of interrupting a short circuit current of 65,000 amperes symmetrical.
18. The breakers shall have high endurance characteristics being capable of no-load and full-load interruptions at rated current equal to or exceeding the UL endurance ratings for power circuit breakers without maintenance.

B. TRIP UNITS

1. Each low-voltage power circuit breaker shall be equipped with a solid-state tripping system consisting of three current sensors, microprocessor-based trip device and flux-transfer shunt trip. The trip unit shall use microprocessor-based technology to provide the basic adjustable time-current protection functions.
2. The trip unit shall be Eaton type Digitrip RMS 1150+ (used with Eaton circuit breakers); MicroLogic H Series (used with Schneider/Square D circuit breakers).
3. The trip unit shall have an information system that utilizes battery backup LEDs to indicate mode of trip following an automatic trip operation. The indication of the mode of trip shall be retained after an automatic trip. A reset button shall be provided to turn off the LED indication after an automatic trip. A test pushbutton shall energize a LED to indicate the battery status.
4. The trip unit shall be provided with a display panel, including a representation of the time/current curve that will indicate the protection functions. The unit shall be continuously self-checking and provide a visual indication that the internal circuitry is being monitored and is fully operational
5. RMS-sensing, microprocessor-based, self-powered, and programmable providing adjustable long-time, short-time, instantaneous, and ground fault protection.
 - a. Short-time and ground fault trip functions shall include I^2t slopes as part of the trip unit programming function.
 - b. Provide trip indicators for long-time, short-time, instantaneous, and ground fault trip indication.
 - c. Provide dry contacts rated for 120 VAC/24VDC for remote SCADA monitoring of breaker open/closed status, trip status, withdrawn status, maintenance mode and other contacts as indicated.
6. All circuit breakers shall be provided with adjustable pick-up settings for long-time, short-time, and ground fault trips and adjustable time delay settings for long-time, short-time, and ground fault settings. Provide all circuit breakers with adjustable and defeatable instantaneous pick-up.
7. Trip settings will be provided by others.
8. The trip unit shall utilize ARMS (Arcflash Reduction Maintenance System). ARMS shall be provided in a system that shall reduce the trip unit Instantaneous pickup value when activated. ARMS device shall not compromise breaker phase protection even when enabled. Once ARMS unit is disabled, the recalibration of trip unit phase protection shall not be required. Activation and deactivation of ARMS setting shall be accomplished without opening the circuit breaker door and exposing operators to

energized parts. ARMS shall provide a clearing time of 0.04 seconds, adjustable with a minimum of five settings ranging from 2.5X to 10X of the sensor value.

- 1) ARMS shall be enabled via a switch on the trip unit. It shall also provide confirmation of protection via a Blue LED.
 - 2) ARMS shall be provided with remote “enable/disable” control
 - 3) ARMS shall be provided with a switchgear panel mounted enable padlockable selector switch and indication via Blue LED pilot light.
 - 4) ARMS shall be wired locally with interposing relays and wired to terminal blocks to enable a remote selector switch and confirmation light to be mounted at the downstream protected distribution equipment.
9. The trip unit shall be equipped to permit communication for remote monitoring and control.
 10. The trip unit shall have provisions for a single test kit to test each of the trip functions.
 11. The test unit shall be as designed and built specifically for the type of circuit breakers being furnished and shall contain necessary cables, plugs and instruction manuals required for operation. Test sets will not be necessary when the circuit breakers trip units include internal test capabilities by an operator.

C. CONTROL POWER TRANSFORMERS

1. Control power transformers shall be provided in each main circuit breaker section to supply power for switchgear space heaters, transfer controls and circuit breaker operating power.
2. The transformer shall be protected by current limiting fuses in a dead front holder on both the primary and secondary.
3. Distribution of control power shall be through use of panel mounted fusible switches, or circuit breakers, properly coordinated.

D. METERING, MONITORING AND CONTROL

1. Where indicated on the drawings, provide a separate owner metering compartment with front hinged door.
2. Provide current transformers for each meter. Current transformers shall be wired to shorting-type terminal blocks.
3. Provide potential transformers including primary and secondary fuses with disconnecting means for metering as shown on the drawings.
4. Meter type to be provided as Eaton PXM 4000, Schenider/Square D PM8000 or equal.
5. Communication protocol: Modbus TCP/IP (Ethernet)
6. Instruments and meters shall be suitable for operating from instrument transformers with nominal 5-ampere and 120 V secondaries.

E. Instrument Transformers

1. Potential Transformers

- a. The quantity, ratio, and connection of potential transformers shall be provided as indicated.
- b. Potential transformers shall be provided with current-limiting high-interrupting-capacity primary fuses in dead front-holders, and shall be mounted in the auxiliary section.

2. Current Transformers

- a. The quantity and ratio of current transformers shall be as indicated and required.
 - b. Current transformers shall have thermal and mechanical ratings and insulation class not less than those of the associated circuit breakers.
 - c. Current transformers shall be mounted in such a way as to provide easy access for inspection and maintenance.
3. Provide test blocks and plugs for current and potential circuits for the main breaker(s).

F. SURGE PROTECTION DEVICES (SPD)

1. Provide as shown on the Contract Drawings. SPDs shall conform to Section 26 43 00 – Surge Protection Devices.
2. SPD units shall be rated for the voltage and phase service of the switchgear at 240 kA per phase.

G. SPARE AND SPACE COMPARTMENTS

1. Circuit breaker compartments, where indicated, shall be completely equipped with drawout rails for the future addition of circuit breakers, including all electrical connections and pilot/control devices.
2. Insulating sleeves shall be provided over the main stationary disconnect studs.
3. Circuit breaker compartments indicated as spares shall be provided with spare circuit breakers of the rating shown, installed and wired.

H. LIFTING DEVICE

1. Provide a top-of-switchgear rail-mounted overhead lighting device and transport dolly for removing the circuit breaker.

I. REMOTE BREAKER RACKING DEVICE

1. Provide a remote breaker racking device to remotely rack and operate a breaker through a 20-foot cord and shall operate from a 120V supply.

2.8 AUTOMATIC THROWOVER SYSTEM

- A. Provide an automatic throwover system for mains utility-generator breakers in open/closed transition system. Open-transition systems require a mechanical interlock between the two main circuit breakers.

1. The following circuit breaker accessories are required for automatic throwover system:
 - a. 120 VAC electrical operation (includes shunt close, shunt trip and electrical operator)
 - b. One set of auxiliary switches (one normally open and one normally closed)
 - c. Alarm switch (one normally open contact)
 - d. Cell position switch (one normally open required for drawout circuit breakers)
 - e. Provide dry contacts for SCADA monitoring
 - f. The following features are required for automatic throwover system:

Description
Automatic transfer to alternate source, automatic retransfer to normal source
Electrically interlocked
Manual circuit breaker close buttons inhibited
Transition delay (2 seconds), open transition
Source loss delay (3 seconds), before transfer
Source stabilization timer (10 seconds) before retransfer
Undervoltage sensing on both sources, standard 100% nominal, 10% differential, adjustable
Phase sequence sensing on both sources, 2 cycles
Phase imbalance, 2%, adjustable
Phase loss, 68% phase loss
Auto/manual keyed switch w/ white light for auto and blue light for manual
Control power transfer

Full automatic mode with drawout breakers in the test position
Open (green) / close (red) lighted push buttons
Test switch—simulates loss of source
Circuit breaker electrical trip lockout w/ amber light indication
Uninterruptible power supply (UPS) for 120 VAC control power
Sources available (white) lights
Operator interface panel
Fused control circuits with individual blown fuse indication
Over-voltage sensing on generator (59), Standard 125% of nominal, 15% differential, adjustable
Frequency sensing on generator (81), standard 3 Hz differential, 0.1–3 Hz, adjustable
Engine start contacts, 5 A @ 120 Vac
Remote alarm contact wired (system inoperative), 5 A @ 120 Vac
Generator exercising unloaded, 30 minutes, once per week
Time delay for engine cool down, 15 minutes unloaded standard
Automatic retransfer to normal switch
Touchscreen HMI
Remote alarm contact (system inoperative), 5 A @ 120 Vac
Time delay for engine cool down, 15 minutes unloaded standard
Generator exercise with load switch

- g. The switchgear shall be provided with controls to perform plant load testing on the generator. One pushbutton shall be provided to transfer plant load to generator and another pushbutton shall be provided to retransfer to utility.

B. CONTROLLER

1. Provide a microprocessor-based controller for automatic transfer and re-transfer between utility and generator power. The controller shall be hardened against potential problems from transients and surges. Operation and monitoring of both

sources shall be managed by the controller. The controller shall be programmed for open transition transfer and re-transfer.

2.9 ENCLOSURES

A. Enclosure

1. Indoor, NEMA Type 1, fully front accessible
2. Each shipping section shall be shipped completely assembled

2.10 NAMEPLATES

- A. Nameplates shall be provided for the front of each compartment and for major devices thereon, such as meters, instruments, control switches, and relays.
- B. Nameplates shall also be provided for major internal devices such as relays, instrument and control power transformers, fuse blocks, switches, and transformers.
- C. Compartment nameplates shall be constructed of 3-layer laminated phenolic plastic, with a black front and back, a white case, and engraved to show white lettering.
- D. The lettering shall be upper case as follows:
 1. one-inch high for switchgear identification
 2. 7/16-inch high for compartment identification
 3. 1/8-inch high for component nameplate
- E. Nameplates that are 1-1/2 inches tall and smaller shall be 1/16-inch thick.
- F. Nameplates larger than 1-1/2 inches tall shall be 1/8-inch thick.
- G. The edges of the nameplates shall be beveled.
- H. Nameplates shall be fastened with black anodized screws.

2.11 SURFACE PREPARATION, PAINTING AND CLEANLINESS

- A. Metal surfaces shall be smooth and free of foreign matter such as scale, sand, blisters, weld splatter, metal chips and shavings, oil, grease, organic matter, and rust, and shall be chemically cleaned and treated in a process which provides a phosphate coating.
- B. Immediately after the treatment process, the surfaces shall be sprayed with coatings of primer and finish paint, and both shall be baked.
- C. Provide an electrostatically deposited powder-coated epoxy finish, oven baked, of one-mil minimum thickness indoor and 2-mils minimum thickness outdoor, and as follows:
 1. Paint surfaces light gray ANSI 61 according to ANSI Z55.1.
 2. The manufacturer's standard practice of double-tone finish on the low-voltage switchgear section is acceptable.

3. Furnish 2 spray cans of air-drying paint of each color tone for field use.

PART 3 -- EXECUTION

3.1 MANUFACTURER'S REPRESENTATIVE

- A. The GENERATOR SUPPLIER shall arrange for a technical service representative of the switchgear manufacturer for pre-commissioning checkout of the equipment and to instruct the operating personnel in the operation, shutdown, startup, and maintenance of the equipment.

3.2 FIELD TESTING, INSPECTION AND STARTUP SERVICES

- A. The GENERATOR SUPPLIER's switchgear manufacturer representative shall support field testing that will be performed by the CONTRACTOR. Assume that field testing will require two days (16 hours) of on-site support.
- B. The GENERATOR SUPPLIER's switchgear manufacturer representative shall provide inspection of the installation to verify correct interconnection wiring and proper installation of the equipment. Assume that the inspection will require two days (16 hours) of on-site support.
- C. The GENERATOR SUPPLIER's switchgear manufacturer representative shall provide startup services to commission the switchgear and transfer controls including, but not limited to the following:
 1. Adjust trip unit settings to match those provided by others
 2. Set up and verify that all metering indicates the proper magnitudes, phase relationships and units.
 3. Set all device clocks (where applicable) to the current correct time. Match multiple clocks as closely as possible.
 4. Apply arc-flash labels to the switchgear. Labels will be provided by others.
 5. Energize the switchgear and commission the generator start/stop and transfer/retransfer controls. Field testing shall include testing of all modes of control (manual/automatic) and verify correct operation of the switchgear. Generator control testing shall be performed in the presence of the OWNER and ENGINEER.
 6. Document all settings as left in the field once the equipment is fully commissioned.

END OF SECTION

SECTION 26 22 00– LOW-VOLTAGE TRANSFORMERS

PART 1 -- GENERAL

1.01 SUMMARY

A. Section Includes

1. The supply of materials, design, assembly, fabrication, testing, and installation of dry-type, general purpose, single and three-phase transformers rated 600V or less.
2. The Contractor shall provide dry-type transformers complete and operable in accordance with this Specification and the Contract Documents.

1.02 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

A. Reference Specifications

01 33 00	Submittal Procedures
26 00 10	Electrical General Requirements
26 01 26	Electrical Tests

B. Reference Standards

UNDERWRITERS LABORATORIES (UL)	
UL 1561	Dry-Type General Purpose and Power Transformers
NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)	
NEMA ST 20	Dry Type Transformers for General Applications
NEMA 250	Enclosures for Electrical Equipment (1000 Volts Maximum)
INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)	
IEEE C57.12.01	IEEE General Requirements for Dry-Type Distribution and Power Transformers (including those with solid-cast and/or resin-encapsulated windings)
IEEE C57.96	IEEE Guide for Loading Dry-Type Distribution and Power Transformers

C. Reference Codes

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)	
NFPA 70	National Electrical Code, 2023 Edition
CSA GROUP (CSA)	

1.03 ACTION SUBMITTALS

- A. General: Submittals shall be made in accordance with Section 01 33 00– Submittal Procedures and Section 26 00 10 – Electrical General Requirements.

LOW-VOLTAGE TRANSFORMERS

B. Product Data

1. Manufacturer's data sheets or catalog pages clearly identifying the make, model, part number, equipment and component ratings, selected options, and selected accessories.

C. Shop Drawings

1. Dimension drawings including details regarding cable/conduit entry and exit locations
2. Winding materials
3. Transformer ratings, including:
 - a. Primary and secondary voltages and winding configurations
 - b. Voltage taps
 - c. kVA ratings
 - d. Number of phases
 - e. Insulation rating and temperature rise
 - f. Impedance
 - g. K-factor, where applicable
 - h. Enclosure type / environmental ratings
4. Descriptive bulletins, including accessories
5. Installation information
6. Seismic certification and equipment anchorage details

D. Test and Evaluation Reports

1. Contractor shall submit, with shop drawings, sample test forms as specified in Section 26 01 26–Electrical Tests.

E. Site Quality Control Submittals

1. Contractor shall submit documentation of successful testing, including completed test forms, as specified in Section 26 01 26–Electrical Tests.

1.04 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data

1. Contractor shall include the following operating and maintenance data for materials and products as per the requirements outlined in Division 01 and Section 26 00 1016010– Electrical General Requirements:

- a. Shop Drawings
 - b. Completed test forms
 - c. Manufacturer's published operation and maintenance procedures
- B. Warranty Documentation
 - 1. Contractor shall provide manufacturer's warranty documentation. Submit this information with the operating and maintenance data.
- C. Record Documentation
 - 1. Contractor shall include as-left transformer tap settings. Submit this information with the operating and maintenance data and as-built drawings.

1.05 DELIVERY, STORAGE, AND HANDLING

- A. Storage and Handling Requirements
 - 1. Contractor shall handle and store the products in accordance with the manufacturer's written requirements.

PART 2 -- PRODUCTS

2.01 GENERAL PURPOSE, DRY-TYPE TRANSFORMERS

- A. Manufacturers
 - 1. Manufacturer List
 - a. Eaton
 - b. Schneider Electric / Square D
 - c. ABB / General Electric
 - d. Siemens
 - e. Hammond Power Solutions
 - f. Approved equal
 - 2. Single Manufacturer
 - a. To achieve standardization of appearance, operation, maintenance and manufacturer's services, all transformers provided shall be the product of one manufacturer.
- B. Materials
 - 1. Ratings

- a. Voltage Ratings (all 60 Hz):
 - 1) 3-Phase, 4-Wire (delta-wye): 480-120/208V
 - b. Continuous kVA Rating:
 - 1) As indicated on drawings.
 - c. BIL Rating:
 - 1) 10 kV BIL
 - d. Voltage Taps:
 - 1) Provide not less than 2 FCAN and 2 FCBN, 2.5% taps.
 - e. Insulation and Temperature Rise (based on 40-degree C ambient):
 - 1) Less than 15 kVA: 180 degree C insulation system based upon 80 degree C rise.
 - 2) 15 kVA and larger: 220 degree C insulation system based upon 80 degree C rise.
 - f. Sound Levels
 - 1) Sound levels shall meet NEMA ST 20 requirements as follows:
 - a) 0-9 kVA - 40dB
 - b) 10-50 kVA - 45dB
 - c) 51-150 kVA - 50dB
 - d) 151-300 kVA - 55dB
 - g. Efficiency
 - 1) Ventilated transformers shall meet the energy efficiency requirements of the Department of Energy, Code of Federal Regulations 10 CFR 431 (DOE 2016) Efficiency Levels.
2. Enclosures
- a. Type:
 - 1) Transformers to be installed in dedicated electrical rooms shall be rated NEMA Type 1. Provide drip hoods where installed in a room containing sprinklers. Finish paint shall be ANSI-61 light gray.
 - b. Vibration isolation:
 - 1) Provide internal and external vibration isolators
3. Windings

- a. Copper
- b. All transformers shall have vacuum pressure impregnated (VPI) core and coils. Transformers shall be ventilated type. Encapsulated transformers may be provided in sizes less than 15 kVA. Non-ventilated enclosures shall not be acceptable.
- c. Impedance: Manufacturer's standard impedance.

4. Accessories

- a. Infrared viewing windows shall be provided to view the transformer terminations for thermal scanning. Windows shall be as manufactured by Flir, Fluke, or approved equal

C. Assembly

1. Seismic Requirements

- a. Equipment design and anchorage methods shall meet the requirements of Section 26 00 10 – Electrical General Requirements and Section

2. Factory Assembly

- a. Transformers shall be fully assembled in the factory.

3. Equipment Identification

- a. Provide equipment identification in accordance with Section 26 00 10 – Electrical General Requirements and Division 01.
- b. Nameplate for each transformer shall be as indicated on the drawings.

2.02 SOURCE QUALITY CONTROL

A. Tests and Inspections

- 1. Transformers shall be tested and inspected prior to shipment in accordance with manufacturer's standard testing procedures.

B. Listings and Certifications

- 1. Transformers shall be designed, constructed and rated in accordance with UL CSA and NEMA standards. Transformers shall be UL listed.

PART 3 -- EXECUTION

3.01 GENERAL

- A. The WORK shall be installed as indicated in Section 26 00 10 – Electrical General Requirements, and as described herein.

3.02 INSTALLATION

A. General

LOW-VOLTAGE TRANSFORMERS

1. Ensure the equipment is properly installed to provide satisfactory service.
2. Remove shipping supports only after transformer is installed and just before placing into service.
3. Loosen isolation pad bolts until no compression is visible.
4. Make primary and secondary connections in accordance with the wiring diagrams.
5. Mount transformers to reduce direct and transmitted noise. Mount core and coils of transformers on vibration and sound absorbing pads.
6. Before energization, keep transformers at no less than 50 degrees F/10 degrees C ambient and protected from moisture and dust.
7. Energize transformers after installation is complete and commissioning tests are performed.
8. Do not use new permanent distribution system dry type transformers for temporary power distribution without permission from the Engineer.

B. Location

1. Locate transformers as indicated on the Drawings.
2. Ensure sufficient working clearance and manufacturer's recommended minimum ventilation space is provided around transformers.

C. Mounting

1. Mount securely in accordance with the manufacturer's written instructions. Ensure the manufacturer nameplates are clearly visible after installation.

D. Grounding

1. Ground the transformer in accordance with Code requirements and the drawings.

3.03 SITE QUALITY CONTROL

A. Site Tests and Inspections

1. Complete testing and document results in accordance with Section 26 00 10—Electrical General Requirements, Section 26 01 26 —Electrical Tests, and the supplementary requirements stated herein.
2. Arrange for proper authorities to witness testing and inspect installation in a manner that avoids duplication of tests.
3. Obtain certificates of approval/acceptance in compliance with rules and regulations of authorities having jurisdiction.

B. Non-Conforming Work

1. Correct all non-conforming work.

2. Re-test and obtain re-inspection.

3.04 SYSTEM STARTUP

A. Manufacturer's Recommendations

1. Prior to starting, obtain and review manufacturer's installation, operation and starting instructions.

3.05 ADJUSTING

A. Voltage Tap Adjustment

1. Record secondary voltage when transformers are carrying approximately 75% of full load. Adjust tap connections to give a continuous secondary phase-to-neutral voltage at the nominal rating. Where the exact nominal rating cannot be met, set primary tap connection to the first tap available that will provide a secondary voltage above the nominal rating rather than below.

3.06 CLEANING

- A. Prior to testing ensure all components are cleaned, vacuumed and free of dust. Do not use compressed air or blowers to clean the equipment.
- B. After testing, protect components from dust and construction activities.

END OF SECTION

SECTION 26 24 16 – PANELBOARDS

PART 1 -- GENERAL

1.01 SUMMARY

A. Section Includes

1. Panelboards for three-phase and single-phase feeder and branch circuit distribution.
2. The Contractor shall provide panelboards complete and operable in accordance with the Contract Documents.

1.02 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

A. Reference Specifications

01 33 00	Submittal Procedures
26 00 10	Electrical General Requirements
26 43 13	Surge Protective Devices for Low-Voltage Electrical Power Circuits
26 08 00	Electrical Tests

B. Reference Standards

UNDERWRITERS LABORATORIES	
UL 67	Panelboards
NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION	
NEMA PB1	Panelboards
NEMA PB1.1	General Instructions for Proper Installation, Operation and Maintenance of Panelboards Rated 600 V or Less
NEMA 250	Enclosures for Electrical Equipment (1000 Volts Maximum)

C. Reference Codes

NATIONAL FIRE PROTECTION ASSOCIATION	
NFPA 70	National Electrical Code, 2023 Edition

1.03 ACTION SUBMITTALS

- A. General: Submittals shall be made in accordance with Section 01 33 00 –Submittal Procedures and Section 26 00 10– Electrical General Requirements.

B. Product Data

1. Manufacturer's data sheets or catalog pages clearly identifying the make, model, part number, equipment and component ratings, selected options, and selected accessories.

C. Shop Drawings

PANELBOARDS

1. Breaker layout drawings with dimensions and nameplate designations
 2. Component list
 3. Drawings of conduit entry/exit locations
 4. Assembly ratings, including:
 - a. Short circuit rating
 - b. Breaker interrupting ratings
 - c. Voltage
 - d. Continuous current
 - e. Enclosure type / environmental ratings
 5. Cable terminal sizes and temperature rating
 6. Descriptive bulletins
 7. Installation information
 8. Seismic certification and equipment anchorage details
- D. Test and Evaluation Reports
1. Contractor shall submit, with shop drawings, sample test forms as specified in Section 26 08 00 – Electrical Tests.
- E. Site Quality Control Submittals
1. Contractor shall submit documentation of successful testing, including completed test forms, as specified in Section 26 08 00 – Electrical Tests.

1.04 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data

1. Contractor shall include the following operating and maintenance data for materials and products as per the requirements outlined in Division 01 and Section 26 00 10 – Electrical General Requirements:
 - a. Shop Drawings
 - b. Completed test forms
 - c. Manufacturer's published operation and maintenance procedures
 - d. List of spare parts

B. Warranty Documentation

1. Contractor shall provide manufacturer's warranty documentation. Submit this information with the operating and maintenance data.

C. Record Documentation

1. Contractor shall include as-built panelboard directories indicating final breaker size and load information. Submit this information as printed (not handwritten) directories with the operating and maintenance data and as-built drawings.

1.05 MAINTENANCE MATERIAL SUBMITTALS

A. Spare Parts

1. Contractor shall provide spare breakers in the size and quantity indicated on the panelboard schedules (refer to Drawings).
2. Where no spares are shown on the Drawings, Contractor shall provide spare breakers in a quantity not less than 10% of breakers shown on schedules. Provide spare breakers installed in available slots.
3. Unless otherwise shown on the Drawings, spare breakers shall be sized 20A,1P for 120/208V or 120/240V panelboards and sized 20A,3P for 480V or 600V panelboards.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Storage and Handling Requirements

1. Contractor shall handle and store the products in accordance with the manufacturer's written requirements.

1.07 WARRANTY

A. Manufacturer Warranty

1. Contractor shall purchase and provide an extended manufacturer's warranty for a total period of X years

PART 2 -- PRODUCTS

2.01 PANELBOARDS

A. Manufacturers

1. Manufacturer List
 - a. Eaton
 - b. Schneider Electric / Square D
 - c. ABB / General Electric
 - d. Siemens
 - e. Approved equal

2. Single Manufacturer

- a. To achieve standardization of appearance, operation, maintenance, spare parts, and manufacturer's services, all panelboards provided shall be the product of one manufacturer.

B. Materials

Ratings

- a. Voltage Ratings:
 - 1) 3-Phase, 4-Wire: 120/208V, .
- b. Continuous Current Rating:
 - 1) As indicated on schedules (see drawings), not less than 100A.
 - 2) Neutral bus shall have the same ampere rating as the main bus.
- c. Short Circuit Ratings:
 - 1) Series ratings are not acceptable.
 - 2) 120/208V panelboards: Bus and breakers shall be rated minimum 10kA (symmetrical); higher where indicated on panelboard schedules.
 - 3) 480V panelboards: Bus and breakers shall be rated minimum 35kA (symmetrical); higher where indicated on panelboard schedules.

2. Enclosures

- a. Type:
 - 1) Panelboards to be installed in dedicated electrical rooms shall be rated NEMA Type 1. Provide drip hoods where installed in a room containing sprinklers. Finish painted ANSI-61 light gray.
 - 2) Panelboards to be installed in any other non-hazardous locations shall be rated NEMA Type 4Xstainless steel.
- b. Features:
 - 1) Hinged doors with combination catch and hatch.
 - 2) Lockable. Key all panelboard locks alike and supply two keys per panel.
 - 3) Panelboards shall be arranged such that when the hinged door is open no energized parts are exposed. All other parts shall be accessible only by removal of a grounded cover plate.
 - 4) Panelboards shall have the necessary barriers, supports, and liberal wiring gutters. Trim screws shall be stainless steel.

PANELBOARDS

- 5) Spaces: Stamp out spaces and install removable fillers where breaker spaces are indicated on schedules.

3. Bus Bars

- a. Tin-plated copper.
- b. Suitable for bolt-on breakers.

4. Circuit Breakers

- a. Bolt-on type with solderless lug load connections. Plug-in circuit breakers will not be acceptable.
- b. Thermal magnetic type with "ON", "OFF" and "TRIPPED" positions. Common trip for two and three pole units. Single pole breakers with handle ties are not acceptable.
- c. Single, two and three-pole as indicated on schedules.
- d. Ampere ratings as indicated on schedules.
- e. Ground Fault Circuit Interrupters (GFCI): Shall provide 5mA ground fault sensitivity in addition to overcurrent protection of the amperage rating indicated on schedules. Wire each GFCI breaker with a separate neutral conductor wired through the interrupter to the ground bus.
- f. Arc Fault Circuit Interrupters (AFCI): Provide UL 1699 combination type single pole 15 or 20 amp AFCI breakers where indicated on schedules
- g. Branch circuit breakers shall be interchangeable and capable of being operated in any position as well as being removable from the front of the panelboard without disturbing adjacent units.
- h. Circuit breakers shall be compatible with clamp-on lockout devices.

C. Assembly

1. Factory Assembly

- a. Panelboards shall be fully assembled in the factory.

2. Equipment Identification

- a. Provide equipment identification in accordance with Section 26 00 10 – Electrical General Requirements and Division 01.
- b. Nameplate for each panelboard shall be as indicated on schedule.

2.02 ACCESSORIES

A. Lockout Devices

1. Provide clamp-on lockout devices compatible with circuit breakers in the following quantities:

- a. Single-pole type: Provide one (1) lockout device for every twelve (12) circuit breakers.
 - b. Two-pole type: Provide one (1) lockout device for every six (6) circuit breakers.
 - c. Three-pole type: Provide one (1) lockout device for every three (3) circuit breakers.
2. Lockout devices shall be pad lockable
- B. Circuit Directory
 1. Circuit directory shall be located on the inside of the front door and shall be laminated.
 2. Provide typewritten directory describing the load and its location for each circuit.
- C. Surge Protection Device (SPD)
 1. Provide integral SPD in all panelboards.
 2. SPDs shall conform to the requirements of Section 26 43 13 – Surge Protective Devices for Low-Voltage Electrical Power Circuits.
 3. SPD units shall be rated for the voltage and phase service of the panel and shall have a surge current rating of 120kA per phase.

2.03 SOURCE QUALITY CONTROL

A. Tests and Inspections

1. Panelboards shall be tested and inspected prior to shipment in accordance with manufacturer's standard testing procedures.

PART 3 -- EXECUTION

3.01 GENERAL

- A. The Work shall be installed as indicated in Section 26 00 10 – Electrical General Requirements, and as described herein.

3.02 INSTALLATION

A. General

1. Ensure the equipment is properly installed to provide satisfactory service.

B. Location

1. Locate panelboards as indicated on the Drawings.
2. Ensure sufficient working clearance is provided around panelboards.

C. Mounting

1. Mount securely, plumb, true and square to adjoining surface. Where located in wet or damp areas, mount the panelboard with ½" space (or larger where required by Code) between the wall and the back of the panelboard.
2. Mount panelboards to height specified in Section 26 00 10 – Electrical General Requirements.

D. Electrical

1. All branch circuit cables shall be bottom entry except for panelboards located in Electrical Rooms and other NEMA 1 areas
2. Connect loads to circuits.
3. For panelboards with neutrals, connect neutral conductor from source to common neutral bus, and from neutral bus to branch circuit and feeder neutrals. Do not mix neutral and ground connections on the same bus.
4. Connect ground bus and connect equipment grounding conductors to the ground bus.

3.03 SITE QUALITY CONTROL

A. Site Tests and Inspections

1. Complete testing and document results in accordance with Section 26 00 10 – Electrical General Requirements, Section 26 01 26 – Electrical Tests, and the supplementary requirements stated herein.
2. Arrange for proper authorities to witness testing and inspect installation in a manner that avoids duplication of tests.
3. Obtain certificates of approval/acceptance in compliance with rules and regulations of authorities having jurisdiction.

B. Non-Conforming Work

1. Correct all non-conforming work.
2. Re-test and obtain re-inspection.

3.04 SYSTEM STARTUP

A. Manufacturer's Recommendations

1. Prior to starting, obtain and review manufacturer's installation, operation and starting instructions.

3.05 ADJUSTING

A. Load Balancing

1. Measure load balance on all panelboards with normal loads (lighting included) operating. Adjust branch circuit connections as required to obtain best balance of current between phases and record changes.

2. If load unbalance exceeds 15%, reconnect circuits to balance loads. Revise panelboard directories and wiring accordingly.
3. Submit, at completion of the Work, a report listing phase and neutral currents on panelboards operating under normal loads. State hour and date on which each load was measured and include voltage at time of test.

3.06 CLEANING

- A. Prior to testing ensure all components are cleaned and free of dust.
- B. After testing, protect components from dust and construction activities.

END OF SECTION

SECTION 26 29 23 – VARIABLE FREQUENCY DRIVE UNITS

PART 1 -- GENERAL

1.1 THE SUMMARY

A. General

1. The VFD SUPPLIER shall provide variable frequency drive (VFD) units, complete and operable, as indicated in accordance with the Contract Documents.
2. Unit Responsibility: A single VFD manufacturer shall be responsible for furnishing the VFDS, to the CONTRACTOR; and for coordination of design, assembly, testing, and installation of each VFD system. Each VFD shall be produced and assembled by the manufacturer at a facility owned or operated by the manufacturer and under the direct supervision and control of the manufacturer. The CONTRACTOR will furnish and/or coordinate all components and accessories as necessary to place the equipment in operation in conformance with the specified performance, features and functions described implicitly herein or implied. The CONTRACTOR shall coordinate between PUMP SUPPLIER and VFD SUPPLIER for confirmation of equipment compatibility.
3. It is the intent of this Section to require complete, reliable, and fully tested variable frequency drive systems suitable for attended or unattended operation.
4. The drive manufacturer shall supply the drive and all necessary options as specified.
5. The VFD SUPPLIER shall provide one (1) VFD for each pump supplied, plus one (1) complete spare VFD, ready for installation.

B. The requirements of Section 26 00 10 – Electrical General Requirements, apply to the WORK of this Section.

C. Single Manufacturer

1. Like products shall be the end product of one manufacturer in order to standardize appearance, operation, maintenance, spare parts, and manufacturer's services.
2. This requirement, however, does not relieve the CONTRACTOR of overall responsibility for the WORK.

D. Coordination

1. Equipment provided under this Section shall operate the electric motor driver and the driven equipment as indicated under other equipment specification Sections.
2. The VFD SUPPLIER'S attention is specifically directed to the need for proper coordination of the WORK under this Section and the WORK under equipment Section with the WORK under Section 26 05 10 – Electric Motors.
3. Pilot devices, relays and other control devices shall meet the requirements of Section 26 05 15 – Industrial Control Panels and Miscellaneous Devices.

1.2 VFD SUPPLIER SUBMITTALS

- A. Furnish submittals in accordance with the requirements of Section 01 33 00 – Submittal Procedures, except that Shop Drawing information for the drives shall be submitted as part of the information for the driven equipment.
- B. Shop Drawings: Include the following information:
 - 1. Elevation Drawings: Include dimensional information and conduit routing locations.
 - 2. Unit Descriptions: Include amperage ratings, enclosure ratings, fault ratings, nameplate information, and so on, as required for approval.
 - 3. Wiring Diagrams:
 - a. Power Diagram: Include amperage ratings, circuit breaker frame sizes, circuit breaker continuous amp ratings, and so on, as required for approval.
 - b. Control Diagram: Include disconnect devices, pilot devices, and so on.
 - 1) Ladder Diagram
 - a) Submit the system schematic ladder diagram and interconnection diagrams.
 - b) The schematic ladder diagram shall include remote devices.
 - c) The ladder diagram shall incorporate the control logic on the corresponding elementary schematic as indicated.
 - d) Submittals with drawings not meeting this requirement will not be reviewed further and will be returned to the VFD SUPPLIER stamped "REJECTED."
 - 4. Major components list.
 - 5. Product Data Sheets
 - a. VFD and Operator Interface publications.
 - b. Data sheets and publications on all major components including, but not limited to, the following:
 - 1) Contactors, if applicable
 - 2) Circuit breaker and fuse (power and control)
 - 3) Control power transformers
 - 4) Pilot devices
 - 5) Relays/Timers
 - 6) dV/dT devices

7) Line Reactors

6. Factory test data certifying compliance of similar equipment from the same manufacturer with requirements of this Section

C. The Technical Manual shall include the following documentation:

1. Manufacturer's warranty (see Section 01 61 10 – Equipment Pre-Procurement – General)
2. harmonic analysis report
3. field test report
4. programming procedure and program settings

D. Spare Parts List

1. Submit information for parts required by this Section plus any other spare parts recommended by the controller manufacturer.

1.3 DELIVERY, STORAGE, AND HANDLING

- A. CONTRACTOR will coordinate the shipping of equipment with the manufacturer.
- B. CONTRACTOR will store the equipment in accordance with the manufacturer's recommendations.

PART 2 -- PRODUCTS

2.1 GENERAL

- A. The VFD SUPPLIER shall provide a total of **four (4)** variable frequency drives.
- B. The VFD's shall be solid state, with a Pulse Width Modulated (PWM) output. The VFD shall be a Sensor-less Vector (DTC) AC to AC converter utilizing the latest Insulated Gate Bipolar Transistor (IGBT) technology.

2.2 The VFD's shall be ultra-low-harmonic, active front end type

- A. Equipment to be operated through variable frequency drives shall include the following:

Quantity	Equipment	HP	Constant or Variable Torque (C/V)	RPM	Bypass (Y/N)	Enclosure Type
4	VFD'S for BOOSTER PUMPS, P-1, P-2, P-3 •VFD-6-P-101 •VFD-6-P-102 •VFD-6-P-103	150	Variable Torque	1800	N	NEMA 12

	• SPARE VFD					
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2.3 EQUIPMENT

A. Ratings

1. The power supply shall be an adjustable frequency inverter designed to convert incoming 3-phase, 480-volt, 60-Hertz power to a DC voltage and then to adjustable frequency AC by use of a 3-phase inverter.
2. The VFD shall employ a full wave rectifier to prevent input line notching and operate at a fundamental (displacement) input power factor of 0.98 at all speeds and nominal load.
3. Current-source inverters will not be accepted.
4. VFDs shall be sized to match the motor current or KVA and inrush characteristics of the motors actually provided.
5. The VFD SUPPLIER shall be responsible for matching the controller to the load (variable torque or constant torque) as well as the speed and current of the actual motor being controlled.

B. Inverter

1. The inverter shall be of a voltage-source design, producing a pulse-width-modulated type output. The VFD shall employ an active AC to DC rectifier (commonly referred to as an active harmonic filter supply unit or "active front end").
2. Six-step and current-source inverters will not be accepted.
3. Inverter shall be an Ultra Low Harmonic construction and shall not contribute any significant harmonics at the input terminals of the VFD. It shall maintain harmonics levels at the VFD input terminals to levels at or below those listed in "Harmonic Control in Electrical Power Systems, IEEE Std. 519-2014.
4. The VFD shall have an active line supply unit which controls the waveform of the input current and reduces the low order harmonic current drawn from the power line. Line currents and voltages shall be nearly sinusoidal. IGBTs shall be used in the rectified and inverter circuits.
5. Each input phase of the VFD shall incorporate a symmetrical LCL filter arranged in a T- configuration. The inductors are to be series power components that carry the full current of the VFD.
6. Inverters shall be capable of delivering the nameplate horsepower exclusive of service factor without the need for mandatory thermostats or feedback tachometers.
7. The VFD shall vary both the AC voltage and frequency simultaneously in order to operate the motor at required speeds. The VFD shall employ an advanced control algorithm (DTC) that provides a steady state speed accuracy within 1/10th the slip without an encoder, for process repeatability and quiet motor operation for audibly friendly working environment.

- C. The minimum VFD inverter efficiency shall be 95 percent at 100 percent speed and load, and 85 percent efficiency at 50 percent speed and load.
- D. Power Outage
1. The VFD shall shut down in an orderly manner when a power outage occurs on one or more phases.
 2. Upon restoration of power and a START signal, the motor shall restart and run at the speed corresponding to the current process input signal.
 3. The VFD shall restart after a power loss without the need to manually reset the VFD as a result of an undervoltage condition.
- E. The VFD shall be provided with the following features:
1. Inrush current adjustment between 50 and 110 percent of motor full load current (factory set at 100 percent)
 2. The short-term normal duty/variable duty overload current capacity shall be 110% of rated current for one (1) minute out of ten (10) minutes.
 3. Adjustable acceleration and deceleration
 4. Input signal of 4 - 20 mA from process and an input signal of 0-10 VDC to accommodate a cabinet door mount speed potentiometer. Upon loss of input signal, the VFD shall operate at a preset speed.
 5. Output motor speed signal and output motor current signal of 4 – 20 mA for each; Signals other than 4 - 20 mA will not be accepted. Outputs shall be independently programmable to provide signals proportional to output function.
 6. The VFD shall have three (3) programmable critical frequency or critical speed lockout ranges to prevent the VFD from operating the load continuously on an undesirable speed range (skip frequencies).
 7. Minimum of six (6) contact inputs which shall be independently programmable with function selections (run/stop, hand-off-auto, etc.). Inputs shall be designed for use with either the VFD's internal 24 VDC supply or a separately furnished external 24 VDC supply. In addition, two (2) digital inputs/outputs shall also be provided. Additional inputs shall be provided as required to meet the requirements of the application as indicated on the control schematics.
 8. Minimum of three (3) form C relay contact outputs shall be provided. Outputs shall be independently programmable. Additional outputs shall be provided as required to meet the requirements of the application as indicated on the control schematics.
 9. Additional devices and functions as indicated on the control schematics.
 10. Provide Ethernet ModbusTCP/IP network communications to transmit VFD data to/from pump station PLC-based control system (control system is supplied by others). The network connection (Modbus TCP/IP) from each VFD shall have all signals mapped.
- F. The VFD shall be provided with, as a minimum, the following protection features:

1. Overvoltage and undervoltage controller. Undervoltage alarms/trips shall automatically reset after restoration of voltage within acceptable limits.
 2. Ground Fault (Earth-leakage) protection and supervision
 3. Motor short-circuit protection
 4. Output and input switch supervision
 5. Overcurrent protection
 6. Protection against single phasing
 7. Instantaneous overcurrent protection
 8. Overtemperature protection for electronics
 9. Protection against internal faults
 10. Phase-loss detection (both motor and line)
 - a. The VFD shall have the capability to continue running at a reduced output current when an input phase-loss is detected.
 - b. The VFD shall have the capability to detect an open circuit on the output of the VFD without the requirement to have the VFD modulating.
 11. Underload and overload supervision
 12. Communication loss functionality to ensure uninterrupted operation.
 13. The VFD shall have the capability to detect cavitation within the pump without need for external devices.
 14. Ability to start into rotating motor (forward or reverse rotation). Additionally, the VFD shall allow for forcing the direction in a given direction, regardless of the speed reference or direction input to the VFD.
 15. The VFD shall be capable of sensing the loss of load (broken belt / broken coupling / dry pump) and signal the loss of load condition. The drive shall be possible to be programmed to signal this condition via a control panel warning, relay output and/or over the communications. The VFD shall include a standard embedded functional safety feature Safe Torque Off, (STO), to make the motor mechanically safe.
 16. Additional protection and control as indicated and as required by the motor and driven equipment.
- G. The VFD shall be designed and constructed to satisfactorily operate within the following service conditions.
1. Elevation
 - a. Elevation to 3300 feet
 2. Ambient Temperature: 0 to 40 degrees C

3. Humidity: 0 to 95 percent, non-condensing
 4. AC Line-Voltage Variation: plus 10 percent to minus 10 percent
 5. AC Line-Frequency Variation: plus and minus 2 Hertz
- H. Electrical equipment provided in addition to the adjustable frequency inverter for each drive shall include:
1. 2-1/2-percent (minimum) line reactor integral to the drive enclosure.
 2. Provide a dV/dT filter device at the motor or VFD output per the VFD manufacturer's recommendation. Submit documentation demonstrating where such devices are required, along with mounting and cabling requirements.
 3. Fused 480-to-120-volt control transformer to provide system control power for the logic and pilot lamps.
 4. Bypass Starters – Not used in this project.
 5. Provide an input circuit breaker or a fused disconnect switch. If a fused input is provided, the VFD shall provide an alarm on a single phase condition.
- I. Inverter Signal Circuits
1. The inverter signal circuits shall be isolated from the power circuits and shall be designed to accept an isolated 4-20 mA signal in the automatic mode of operation.
 2. The inverter shall follow the setting of a VFD face-mounted potentiometer control while in the manual mode.
 3. Refer to the Elementary Schematic indicated on the Drawings for speed control and START/STOP methods.
 4. Access to set-up and protective adjustments shall be protected by key-lockout or a keypad parameter accessed password.
 5. The following operator monitoring and control devices for the inverter shall be provided on the face of the VFD enclosure, either as specified discrete devices or as part of a multi-function microprocessor-based keypad access device:
 - a. AUTO/HAND selection from a remote logic relay or switch.
 - b. While in AUTO, the inverter shall operate from the remote 4-20 mA input, and while in HAND control shall operate from a local manually operated speed potentiometer and stop and start pushbuttons.
 - c. Speed indicator calibrated in percent speed.
 - d. Furnish cabinet door mounted inverter fault trip pilot light and output alarm contacts.
 - e. External fault pilot light and output alarm contacts.

- f. VFD cabinet door mounted "reset" pushbutton with a parallel circuit to accommodate a remote "reset" pushbutton or PLC reset output.
 - g. Furnish pushbuttons, indicating lights, relays and other controls as indicated on the control schematics.
 - h. Provide other controls and readouts normally furnished as standard equipment, or as otherwise indicated on the control schematics indicated on the Drawings.
- J. Properly identified screw type terminal boards shall be provided for interconnection to remote controls and instrumentation.

2.4 HARMONIC ANALYSIS FOR DRIVES

- A. The VFD Supplier (to the VFD SUPPLIER) shall perform a harmonic study of the facilities included in this Project.
- B. The following assumptions shall be utilized for the harmonic analysis:
 - 1. The distribution system is a "general" system as classified by IEEE 519 under low voltage systems.
 - 2. Assume 90 percent of total plant operating load is motor load and 10 percent is resistive.
 - 3. Assume a 70 percent plant diversity factor (i.e., 70 percent of the total plant load is operating), with motors other than VFDs operating at 90 percent of their nameplate horsepower.
 - 4. Assume only 2 VFD controlled pumps are operating at a time
 - 5. Report
 - a. Results of the harmonic analysis shall be submitted prior to VFD shipment.
 - b. Excessive harmonic distortion shall be specifically denoted.
 - c. Corrective measures shall be submitted for action by the ENGINEER.

2.5 SPARE PARTS

- A. The VFD SUPPLIER shall furnish the spare parts listed below, suitably packaged and labeled with the corresponding equipment number. In addition to the three (3) pump VFDs, a complete, ready-to-install, spare VFD shall be provided.
- B. Modified Parts
 - 1. At any time prior to Substantial Completion, the VFD SUPPLIER shall notify the ENGINEER in writing about any manufacturer's modification of spare part numbers, interchangeabilities, or model changes.
 - 2. If the ENGINEER determines that the modified parts no longer apply to the equipment provided, the VFD SUPPLIER shall furnish other applicable parts as part of the WORK.

C. The following spare parts shall be furnished:

1. Provide one set of spare power fuses of each form, voltage, and current rating.
2. Provide 10 spare control fuses of each type and rating.
3. Provide 3 panel lamps of each type (form, voltage, and current rating).

2.6 Manufacturers (no equal)

A. **ABB – ACS 880**

1. The VFDs shall be manufactured by ABB Industrial Systems and the Integrated Pump Controllers shall be furnished, designed, and integrated by Zesco Inc., 6500 Miller Road, Brecksville, Ohio (440-586-0603). This is a proprietary equipment supply requirement – no alternative manufacturers/suppliers will be permitted.

PART 3 -- EXECUTION

3.1 MANUFACTURER'S SERVICES

- A. Factory trained application engineering and service personnel that are trained on the VFD products offered shall be locally available at both the specifying and installation locations.
- B. Training shall include installation, programming, and operation of the VFD, and serial communication. Factory authorized start up and owner training to be provided locally upon request.
- C. An authorized service representative of the manufacturer shall be present at the Site for 3 Days to furnish the services listed below.
- D. For the purpose of this Paragraph, a Day is defined as an 8-hour period excluding travel time.
- E. The authorized service representative shall supervise the following and shall certify that the equipment and controls have been properly installed, aligned, and readied for operation:
 1. installation of the equipment
 2. inspection, checking, and adjusting the equipment.
 3. startup and field testing for proper operation
 4. performing field adjustments such that the equipment installation and operation comply with requirements.
- F. Instruction of OWNER's Personnel
 1. The authorized representative shall instruct the OWNER's personnel in the operation and maintenance of the equipment, including step-by-step troubleshooting with test equipment.

2. The instruction shall be specific to the VFD models provided.
3. Training shall be scheduled a minimum of 3 weeks in advance of the first session.
4. Training shall include individual sessions for one group of up to six (6) participants.
5. Proposed training materials shall be submitted for review, and comments shall be incorporated.
6. Training materials shall remain with the trainees.
7. The OWNER may record the training for later use with the OWNER's personnel.

3.2 INSTALLATION

- A. Installation will be performed by the CONTRACTOR (see Division 1 specifications for additional details.)
- B. Programming
 1. The VFD Supplier (through the VFD SUPPLIER) shall perform programming of drive parameters required for proper operation of the VFDs included in this project.
 2. Submit records of programming data in the equipment Technical Manual, including setup and protective settings.

3.3 FIELD TESTING

- A. Testing, checkout, and startup of the VFD equipment in the field shall be performed under the technical direction of the VFD SUPPLIER's service engineer.
- B. Under no circumstances shall any portion of the drive system be energized without authorization from the VFD SUPPLIER's representative.
- C. Verify proper operation of control logic in every mode of control.

END OF SECTION

SECTION 26 32 13 - STANDBY POWER GENERATION

PART 1 -- GENERAL

1.1 THE REQUIREMENT

- A. The GENERATOR SUPPLIER shall furnish an engine-driven standby electrical generating system complete and operable, in accordance with the Contract Documents.
- B. The GENERATOR SUPPLIER shall be responsible for coordination of interface with other equipment furnished as part of this procurement contract.
- C. Unit Responsibility: A single generator manufacturer shall be responsible for furnishing the generators, to the CONTRACTOR; and for coordination of design, assembly, testing, and installation of the generator system. The generator shall be produced and assembled by the manufacturer at a facility owned or operated by the manufacturer and under the direct supervision and control of the manufacturer. The CONTRACTOR will furnish and/or coordinate all components and accessories as necessary to place the equipment in operation in conformance with the specified performance, features and functions described implicitly herein or implied.

1.2 SUMMARY

- A. This section includes packaged engine-generator set for standby power with the following features:
 - 1. Diesel engine
 - 2. Unit mounted cooling system
 - 3. Unit mounted control and monitoring with connections to plant SCADA system
 - 4. Performance requirements for sensitive loads
 - 5. Fuel system
 - 6. Outdoor enclosure
 - 7. Exhaust
 - 8. Mounting
 - 9. Air make-up system
 - 10. Outdoor lighting and receptacles as required
 - 11. Indoor lighting and receptacles as required

1.3 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

- A. Materials shall conform with applicable requirements of the National Electrical Code (NEC), and any other State or Municipal codes which apply. Generator system shall meet applicable standards and codes, including IEEE, NEMA, ANSI, OSHA, and UL.

B. Related Sections

- a. Section 01 33 17 – Structural Design, Support and Anchorage
- b. Section 01 61 10 – Equipment Pre-Procurement – General
- c. Section 26 11 10 – Low-Voltage Switchgear
- d. Section 26 43 00 – Surge Protection Devices (SPD)

1.4 SUPPLIER SUBMITTALS

A. Furnish submittals in accordance with Section 01 33 00 - Submittal Procedures and Section 26 00 10 – Electrical General Requirements.

B. Shop Drawings

- 1. Detailed, dimensioned Shop Drawings and data demonstrating adherence to the requirements of these specifications shall be submitted and approved before fabrication, shipment, or other WORK under this Section begins. Include the manufacturer's certification that engine atmospheric emissions will comply with the limitations.
- 2. **Bill of Materials:** A listing shall include all panels, racks, instruments, components, and devices provided under this section.
- 3. **Product Data:** Engine-generator submittals shall include the following information:
 - a. Factory published specification sheet.
 - b. Manufacturer's catalog cut sheets of all auxiliary components such as battery charger, control panel, enclosure, etc. Dimensional elevation and layout drawings of the generator set enclosure and transfer switchgear and related accessories.
 - c. Weights of all equipment.
 - d. Concrete pad recommendation, layout, and stub-up locations of electrical and fuel systems.
 - e. Interconnect wiring diagram of complete emergency system, including generator, switchgear, day tank, remote pumps, battery charger, control panel, and remote alarm indications.
 - f. Engine mechanical data, including heat rejection, exhaust gas flows, combustion air and ventilation air flows, fuel consumption, etc.
 - g. Generator electrical data including temperature and insulation data, cooling requirements, excitation ratings, voltage regulation, voltage regulator, efficiencies, waveform distortion and telephone influence factor.
 - h. Generator resistances, reactances and time constants.
 - i. Generator locked rotor motor starting curves.

- j. Manufacturer's documentation showing maximum expected transient voltage and frequency dips, and recovery time during operation of the generator set at the specified site conditions with the specified loads.
 - k. Warranty.
 - l. Manufacturer's written storage and handling procedures.
 - m. Manufacturer's written installation procedures.
4. Engine-generator unit and accessories shall include:
- a. Enclosure
 - b. Accessory sub-panel and transformer
 - c. Control panel
 - d. Voltage regulator
 - e. Fuel system
 - f. Exhaust system
 - g. Batteries
 - h. Battery charger
 - i. Jacket water heater
5. Generator circuit breaker
- a. Catalog data
 - b. Recommended trip settings for all adjustable settings
 - c. Short circuit interrupt ratings
- C. **Shop Drawings:** Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection. all connections for fuel, cooling, exhaust, direct current connections, conduit locations, and connections for control and power wiring.
- 1. Dimensioned outline plan and elevation drawings of engine-generator set and other components specified.
 - 2. Outline drawings and connection diagrams shall be complete enough to enable the installation to be designed completely, and connection diagrams shall give both internal and external connections. Include foundation loading and clearances.
 - 3. Design Calculations: Signed and sealed by a qualified professional engineer. Calculate requirements for selecting vibration isolators and vibration isolation bases.
 - 4. Vibration Isolation Base Details: Signed and sealed by a qualified professional engineer. Detail fabrication, including anchorages and attachments to structure and to supported equipment. Include base weights.

5. Wiring Diagrams: Power, signal, and control wiring.

- a. Certified custom drawings and custom wiring diagrams of each component in the system and a master wiring diagram showing the entire system on one sheet. This diagram shall include all AC and DC power control connections between the generator, engine, fuel tank system, batteries, and circuit breakers and shall be a custom drawing for this specific installation.
 - b. Include wire and terminal numbers for all diagrams.
6. Provide an electronic draft copy of complete and detailed instructions for operation and maintenance of the standby engine generator system for ENGINEER review and comment. Once comments are addressed, provide two (2) hard copies and one (1) electronic copy of the final manual to the OWNER. The manuals shall be furnished after final approval of shop and working drawings but just prior to shipment of equipment. Manuals shall be complete with wiring diagrams, lubrication schedules and recommended lubricants, drawings, cuts, parts lists, and other necessary data. All parts shall be numbered or otherwise clearly identified to facilitate ordering of replacements. Descriptions of all operational control devices and their functions shall also be included.

1.5 QUALITY ASSURANCE

- A. The engine/generator shall be the product of a manufacturer who has been regularly engaged in the design and production of similar engine/generator sets for a minimum of 10 years.
- B. Authorized Representative Qualifications: Manufacturer's authorized representative who is trained and approved for inspection of installation of units required for this Project.
 1. Maintenance Proximity: Not more than two (2) hours' normal travel time from authorized representative's place of business to Project site.
 2. Engineering Responsibility: Preparation of data for vibration isolators and seismic restraints of engine skid mounts, including Shop Drawings, based on testing and engineering analysis of manufacturer's standard units in assemblies similar to those indicated for this Project.
- C. Manufacturer Qualifications: A qualified manufacturer with a minimum of 25 years' experience building the specified products. The manufacturer shall maintain, 50 miles of Project site, a factory authorized and trained service center capable of providing training, parts, and emergency maintenance repairs.
- D. Source Limitations: Obtain packaged generator sets and auxiliary components through one source from a single manufacturer.
- E. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- F. Comply with ASME B15.1.
- G. Comply with NFPA 37.

- H. Comply with NFPA 70.
- I. Comply with NFPA 99.
- J. Comply with NFPA 110
- K. Listed to UL 2200 (600V generator output and below)
- L. Exhaust Emissions: Comply with applicable federal, state, and local emissions requirements at the time of installation and commissioning.
- M. Sound emissions: Comply with applicable local sound requirements.

1.6 WARRANTY

- A. See Section 01 61 10 – Equipment Pre-Procurement – General for warranty information.
 - 1. The GENERATOR SUPPLIER's warranty shall include repair parts, labor, reasonable travel expense necessary for repairs at the job site, and expendables (lubricating oil, filters, antifreeze, and other service items made unusable by the defect) used during the course of repair. Submittals received without written warranties as specified will be rejected in their entirety.

1.7 MAINTENANCE SERVICE

- A. The engine GENERATOR SUPPLIER shall maintain 24 hour parts and service capability within 50 miles of the project site. The distributor shall stock parts as needed to support the generator set package for this specific project. The distributor shall carry sufficient inventory to cover no less than 80% of the parts service within 24 hours and 95% within 48 hours.
- B. Initial Maintenance Service: Beginning at Acceptance, provide 12 months' full maintenance by certified employees of manufacturer's designated service organization. Include semi-annual exercising to check for proper starting, load transfer, and running under load. Include routine preventive maintenance as recommended by manufacturer and adjusting as required for proper operation. Provide parts and supplies same as those used in the manufacture and installation of original equipment.

1.8 PROJECT CONDITIONS

- A. Environmental Conditions: Engine-generator system shall withstand the following environmental conditions without mechanical or electrical damage or degradation of performance capability:
 - 1. Ambient Temperature: Minus 25°C to plus 50 °C.
 - 2. Altitude: Sea level to 3000 ft.

PART 2 -- PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide product by the following:

1. **Caterpillar Inc. (Design is based on Caterpillar)**
2. **Or Equal by Cummins Inc. (See Section 01 60 00 – Products, Materials, Equipment and Substitutions)**

2.2 SYSTEM COMPONENTS

- A. The equipment package shall include in general, and as applicable, engine and generator on a common vibration isolating base, with auxiliaries, accessories, and controls, including intake filters, discharge silencer, turbocharger, heat exchangers, foundation bolts, isolators, piping, flexible couplings, supports, complete exhaust piping, ring, and silencer, insulation, control panels, lubrication system, water jacket heaters, cooling system, fuel tank, batteries and battery rack, battery charger, spare parts, and all materials necessary to permit installation, testing and placing the system in successful operation.

2.3 ENGINE-GENERATOR SET

- A. Provide one new diesel engine-powered electric generator set, in an outdoor, waterproof, sound attenuated enclosure.

B. **Generator set Requirements.**

1. Standby Duty rated at 400 ekW, 500 kVA
2. 1800 RPM, 0.8 power factor, 480 V, 3 phase, 4 wire, 60 Hertz.
3. Generator set shall be sized to operate at the specified load at a maximum ambient of 84F (28.9C) and altitude of 1000 feet (305 m).
4. Standby Power Rating:
 - a. Power is available for the duration of an emergency outage.
 - b. Average Power Output = 70% of standby power
 - c. Load = Varying
 - d. Typical Hours/Year = 200 Hours
 - e. Maximum Expected Usage = 500 hours

- C. Mounting Frame: Maintain alignment of mounted components without depending on concrete foundation, with provisions for lifting attachments.

1. Rigging diagram shall be permanently attached to the generator set package to indicate location and lifting capacity of each lifting attachment and generator-set center of gravity

D. Generator set performance:

1. Steady-State Voltage Operational Bandwidth: 3 percent of rated output voltage from no load to full load.

2. Transient Voltage Performance: Not more than 20 percent variation for 50 percent step-load increase or decrease. Voltage shall recover and remain within the steady-state operating band within three seconds.
3. Steady-State Frequency Operational Bandwidth: 0.5 percent of rated frequency from no load to full load.
4. Steady-State Frequency Stability: When system is operating at any constant load within the rated load, there shall be no random speed variations outside the steady-state operational band and no hunting or surging of speed.
5. Transient Frequency Performance: Less than 5 percent variation for 50 percent step-load increase or decrease. Frequency shall recover and remain within the steady-state operating band within five seconds.
6. Output Waveform: At no load, harmonic content measured line to line or line to neutral shall not exceed 5 percent total and 3 percent for single harmonics. Telephone influence factor, determined according to NEMA MG 1, shall not exceed 50 percent.
7. Sustained Short-Circuit Current: For a 3-phase, bolted short circuit at system output terminals, system shall supply a minimum of 250 percent of rated full-load current for not less than 10 seconds and then clear the fault automatically, without damage to generator system components.
8. Start Time: Comply with NFPA 110, Type 10, system requirements.

2.4 SYSTEM OPERATION

A. The system shall operate as follows:

1. Automatic Control

- a. A maintained remote contact closure from the automatic transfer controller (part of switchgear, SWGR-1 under section 26 11 10 Low-Voltage Switchgear shall cause the generator-set to start and run.
- b. When the remote startup contact opens, the engine shall continue to operate for an adjustable cool-down time (typically 5 to 30 minutes).
2. **Local Control:** The generator-set shall be capable of manual initiation or stopping from the locally mounted generator control panel. The local generator control panel shall be provided as part of this Contract.
3. **Emergency Stop Control:** Three (3) emergency stop pushbuttons shall be provided. One shall be at the generator control panel. The other two emergency stop pushbuttons shall be on the outside of the enclosure, near each door. All three buttons shall cause the unit to stop without any delay. Indication of an emergency stop situation shall be available as a hardwired output dry contact rated 10A at 120V, and shall be available over the Modbus connection. Outdoor pushbuttons shall be NEMA 3R rated.

2.5 ENGINE

- A. The engine shall be diesel fueled, four (4) cycle, water-cooled, while operating with nominal speed not exceeding 1800 RPM.
- B. Fuel: Fuel oil, Grade DF-2 ULS type
- C. **Lubrication system:** The following items are mounted on engine or base rails:
 - 1. Filter and strainer: Oil filters rated to remove 90% of particles 5 micrometers and smaller while passing full flow
 - 2. Lube oil pump
 - 3. Oil level regulator
 - 4. Crankcase Drain: Arranged for complete gravity drainage to an easily removable container with no disassemble and without use of pumps, siphons, special tools, or appliances
- D. **Engine Fuel System:** The fuel system shall be integral with the engine. In addition to the standard fuel filters provided by the engine manufacturer.
 - 1. Main Fuel Pump: Mounted on engine. Pump ensures adequate primary fuel flow under starting and load conditions.
 - 2. Relief-Bypass Valve: Automatically regulates pressure in fuel line and returns excess fuel to source.
 - 3. Provide primary water separator and fuel filters in the fuel inlet line to the engine. Fuel filters shall have isolation valve for changing of filters during engine operation.
 - 4. All fuel piping shall be black iron or flexible fuel hose rated for this service. No galvanized piping will be permitted. Flexible fuel lines shall be minimally rated for 300 degrees F and 100 psi
- E. **Jacket Water Heater:** Electric-immersion type, factory installed in coolant jacket system. Comply with NFPA 110 requirements for Level 1 equipment for heater capacity. Heater shall include a circulation pump. Provide isolation valves that allow for change out of the heater without having to drain the entire system. The jacket water heaters shall be **of 2.25kW, 208 volt, 1 phase**, thermostatically controlled. Power shall be derived from a load center, as indicated on the contract drawings.
- F. **Governor:** Shall provide isochronous control, with provisions to interface with load share modules and / or remote switchgear. The engine governor shall be an electronic Engine Control Module (ECM) with 24-volt DC Electric Actuator. The ECM shall be enclosed in an environmentally sealed, die-cast aluminum housing which isolates and protects electronic components from moisture and dirt contamination. The ECM shall adjust fuel delivery per exhaust smoke, altitude and cold mode limits. In the event of a DC power loss, the forward acting actuator will move to the minimum fuel position.

G. **Cooling System:** Closed loop, liquid cooled, with radiator factory mounted on engine-generator-set mounting frame, radiator duct flange and integral engine-driven coolant pump.

1. Coolant: Solution of 50 percent ethylene-glycol-based antifreeze and 50 percent water, with anticorrosion additives as recommended by engine manufacturer.
2. Size of Radiator: Adequate to contain expansion of total system coolant from cold start to 100 percent load condition to an ambient temperature of 104°F / 40°C ambient. Radiator shall be capable of providing cooling for an external restriction of 1.0 inch of water column.
3. Expansion Tank: Constructed of welded steel plate and rated to withstand maximum closed-loop coolant system pressure for engine used. Equip with gage glass and petcock.
4. Temperature Control: Self-contained, thermostatic-control valve modulates coolant flow automatically to maintain optimum constant coolant temperature as recommended by engine manufacturer.
5. Coolant Hose: Flexible assembly with inside surface of nonporous rubber and outer covering of aging-, ultraviolet-, and abrasion-resistant fabric.
6. Rating: 50-psig (345-kPa) maximum working pressure with coolant at 180°F (82°C), and non-collapsible under vacuum.
7. End Fittings: Flanges or steel pipe nipples with clamps to suit piping and equipment connections.
8. Integral fuel oil cooler shall be provided as required by the OEM.

H. **Starting System:** 24 VDC electric with negative ground

1. Dual cranking motor: Dual electric starters that automatically engage and release from engine flywheel without binding.
2. Cranking cycle: as required by NFPA 110 for system level Type 1

I. **Battery:**

1. Oversize (10%) capacity to accommodate starting within ambient temperature range specified in Part 1 "Project Conditions" article to provide specified cranking cycle at least three times without recharging.
2. Provide a lead acid storage battery with sufficient capacity for three 30 second cranking cycles, allowing 10 seconds between cycles. Submit calculations verifying adequate capacity. The battery shall be on a plastic rack as close as practical to the starter motor. The CONTRACTOR shall provide vented, nonmetallic protective covers or red and black plastic or rubber boots covering all terminals to protect against an accidental short circuit as might be caused by laying a metallic object on the battery. Metallic racks and covers are not acceptable.

3. **Battery Cable:** Size as recommended by engine manufacturer for cable length required as per site conditions to be field verified by manufacturer's representative prior to order. Include required interconnecting conductors and connection accessories.
- J. **Battery-Charging Alternator:** Factory mounted on engine with solid-state voltage regulation and 35-A minimum continuous rating.
- K. **Battery Charger:** Unit-mounted, 120V, Current-limiting, automatic-equalizing and float-charging type. Unit shall comply with UL 1236 and include the following features:
1. **Operation:** Equalizing-charging rate of 10 A shall be initiated automatically after battery has lost charge until an adjustable equalizing voltage is achieved at battery terminals. Unit shall then be automatically switched to a lower float-charging mode and shall continue to operate in that mode until battery is discharged again.
 2. **Automatic Temperature Compensation:** Adjust float and equalize voltages for variations in ambient temperature from -40°C to +60°C to prevent overcharging at high temperatures and undercharging at low temperatures.
 3. **Automatic Voltage Regulation:** Maintain constant output voltage regardless of input voltage variations up to $\pm 10\%$.
 4. **Ammeter and Voltmeter:** Flush mounted in door. Meters shall indicate charging rates.
 5. **Safety Functions:** Sense abnormally low battery voltage and close contacts providing low battery voltage indication on control and monitoring panel. Sense high battery voltage and loss of ac input or dc output of battery charger. Either condition shall close contacts that provide a battery-charger malfunction indication at system control and monitoring panel.
 6. The battery charger shall include alarm relays to sense high and low dc voltage, zero current, and ac power failure, with individual output contacts wired to terminal strips for tie into remote alarms. Also, provide an ac "on" indicating pilot LED light and dc voltmeter and ammeter and annunciator.
 7. **Enclosure and Mounting:** NEMA 250, Type 1, wall-mounted cabinet.
 8. Engine shall be provided with high temperature, low oil and overspeed shutdown protection system

2.6 COOLING SYSTEM

- A. The engine shall be equipped with a cooling system having sufficient capacity to effectively cool the engine when delivering full rated horsepower at the conditions stated above. A radiator and engine-driven fan of a type and capacity recommended by the engine manufacturer shall be included.
- B. The radiator shall be sized in accordance with the engine manufacturer's recommendation for use with 50 percent aqueous ethylene glycol. Air flow shall be controlled by a power inlet damper and a gravity discharge damper, both provided as

part of the walk-in outdoor enclosure. Design ambient air temperature shall be 100 degrees F at sea level.

- C. The engine shall have an engine-driven, gear driven centrifugal type water circulating pump for circulating water through the cooling system.

2.8 GENERATOR

- A. The synchronous three phase generator shall be a single bearing, self-ventilated, drip-proof design in accordance with NEMA MG 1 and directly connected to the engine flywheel housing with a flex coupling. The excitation system shall be of brushless construction and be independent of main stator windings. Provide radio-interference suppression meeting commercial standards.
- B. If a line to neutral short circuit occurs, the generator shall be capable of supporting 300 percent rated current for 10 seconds without externally mounted devices.
- C. Voltage Regulation Tolerance: Plus or minus 1 percent of any present value over the 3 phase load range. Instantaneous voltage dip or rise, when measured with an oscilloscope, shall not exceed 25 percent upon full load application or rejection, and shall return to preset value within 0.5 seconds.
- D. Waveform: Deviation factor of output voltage shall not exceed 5 percent and the value of any individual harmonic shall not exceed 2 percent of the fundamental when operating with an unbalanced load.
- E. Temperature Rise: Temperature rise of any component shall not exceed the rise permitted by NEMA standards. The voltage regulator shall be adjustable minus 25 percent to plus 10 percent.
- F. Bearing: Double sealed ball bearing, lubricated for life.

2.9 GENERATOR OVERCURRENT AND FAULT PROTECTION

- A. Generator Protector: Microprocessor-based unit shall continuously monitor current level in each phase of generator output, integrate generator heating effect over time, and predict when thermal damage of alternator will occur. When signaled by generator protector or other generator-set protective devices, a shunt-trip device in the generator disconnect switch shall open the switch to disconnect the generator from load circuits. Protector shall perform the following functions:
 - 1. Initiates a generator overload alarm when generator has operated at an overload equivalent to 110 percent of full-rated load for 60 seconds. Indication for this alarm is integrated with other generator-set malfunction alarms.
 - 2. Under single or three-phase fault conditions, regulates generator to 300 percent of rated full-load current for up to 10 seconds.
 - 3. As overcurrent heating effect on the generator approaches the thermal damage point of the unit, protector switches the excitation system off, opens the generator disconnect device, and shuts down the generator set.
 - 4. Senses clearing of a fault by other overcurrent devices and controls recovery of rated voltage to avoid overshoot.

B. Generator Circuit Breaker:

1. Provide a 800A, UL Listed, molded-case, electronic-trip type; 100% rated; complying with UL 489. Circuit breaker shall be unit mounted, NEMA 4X enclosure which is isolated from vibrations induced by the generator set. Stand-alone circuit breaker structures will not be accepted. See the Single-Line Diagram Contract Drawing for more information.
2. Breaker shall utilize a solid state trip unit. The breaker shall be UL/CSA Listed Shunt Trip: Connected to trip breaker when generator set is shut down by other protective devices.
 - a. Tripping Characteristics: LSIG; Adjustable long-time and short-time delay and instantaneous and ground fault.
 - b. Trip Settings: Selected to coordinate with generator thermal damage curve and downstream devices.
 - c. Shunt Trip: Connected to trip breaker when generator set is shut down by overcurrent conditions

2.10 VIBRATION ISOLATION DEVICES

- A. Elastomeric Isolator Pads: Oil- and water-resistant elastomer or natural rubber, arranged in single or multiple layers, molded with a nonslip pattern and galvanized-steel baseplates of sufficient stiffness for uniform loading over pad area, and factory cut to sizes that match requirements of supported equipment.
 1. Material: Bridge-bearing neoprene, complying with AASHTO M 251.
 2. Durometer Rating: 60* (*to be confirmed by manufacturer based on final selection of vibration isolation system.)
 3. Number of Layers: up to Four (determined by manufacturer based on final vibration isolator assembly design)

2.11 LUBRICATION AND COOLING FLUIDS

- A. The GENERATOR SUPPLIER shall furnish the engine fully charged with lubricating oil and grease as specified by the manufacturer for continuous service. The cooling system shall be furnished with a full charge of 50 percent ethylene glycol.

2.12 GENERATOR CONTROLS AND MONITORING

- A. Provide a fully solid-state, microprocessor based, generator set controller. The control panel shall be designed and built by the engine manufacturer. The controller shall provide all operating, monitoring, and control functions for the generator set. The control panel shall provide real time digital communications to all engine and regulator controls via secure communication network.
- B. **Mounting:** The control panel shall be mounted on the generator set

C. Environmental

1. The generator set controller shall be tested and certified to the following environmental conditions:

- a. -40°C to +70°C Operating Range
- b. 100% condensing humidity, 30°C to 60°C
- c. IP22 protection for rear of controller; IP55 when installed in control panel
- d. 5% salt spray, 48 hours, +38°C, 36.8V system voltage
- e. Sinusoidal vibration 4.3G's RMS, 24-1000Hz
- f. Electromagnetic Capability (89/336/EEC, 91/368/EEC, 93/44/EEC, 93/68/EEC, BS EN 50081-2, 50082-2)
- g. Shock: withstand 15G

D. **Functional Requirements:** The following functionality shall be integral to the control panel.

1. The control shall include a minimum 5.5 inch, 480 x 320 pixel, white backlit graphical display with text based alarm/event.
2. The control shall include a minimum of 6-line data display.
3. Generator set overview screen displaying critical generator set mechanical and electrical data on a single screen
4. Audible horn for alarm and shutdown with horn silence switch
5. Standard ISO labeling
6. Multiple language capability
7. Remote start/stop control
8. Local run/off/auto control integral to system microprocessor
9. Cooldown timer
10. Speed adjust
11. Lamp test
12. Emergency stop push button
13. Voltage adjust
14. Voltage regulator V/Hz slope - adjustable
15. Password protected system programming

E. **Digital Monitoring Capability:** The controls shall provide the following digital readouts for the engine and generator. All readings shall be indicated in either metric or English units.

1. Engine

- a. Engine oil pressure
- b. Engine oil temperature
- c. Engine coolant temperature
- d. Engine RPM
- e. Battery volts
- f. Engine hours
- g. Engine crank attempt counter
- h. Engine successful start counter
- i. Service maintenance interval
- j. Real time clock
- k. Engine exhaust stack temperature
- l. Engine main bearing temperature

2. Generator

- a. Generator AC volts (Line to Line, Line to Neutral and Average.
- b. Generator AC current (Avg and Per Phase.
- c. Generator AC Frequency
- d. Generator kW (Total and Per Phase.
- e. Generator kVA (Total and Per Phase.
- f. Generator kVAR (Total and Per Phase.
- g. Power Factor (Avg and Per Phase.
- h. Total kW-hr
- i. Total kVAR-hr
- j. % kW
- k. % kVA
- l. % kVAR
- m. Generator bearing temperature
- n. Generator stator winding temperature
- o. Real (kW. Load Histogram – which tracks time that the generator kW is within predefined ranges

F. **Alarms and Shutdowns:** The control shall monitor and provide alarm indication and subsequent shutdown for the following conditions. All alarms and shutdowns are

accompanied by a time, date, and engine hour stamp that are stored by the control panel for first and last occurrence:

1. Engine Alarm/Shutdown

- a. Low oil pressure alarm/shutdown
- b. High coolant temperature alarm/shutdown
- c. Loss of coolant shutdown
- d. Overspeed shutdown
- e. Overcrank shutdown
- f. Emergency stop shutdown
- g. Low coolant temperature alarm
- h. Low battery voltage alarm
- i. High battery voltage alarm
- j. Control switch not in auto position alarm
- k. Battery charger failure alarm

2. Generator Alarm/Shutdown

- a. Generator phase sequence
- b. Generator over voltage
- c. Generator under voltage
- d. Generator over frequency
- e. Generator under frequency
- f. Generator reverse power (real and reactive).
- g. Generator overcurrent (including inverse definite minimum time for Normally Inverse, Very Inverse, Extremely Inverse conditions as well as those based on Thermal Damage Curve configurations)
- h. Generator current balance

3. Voltage Regulator Alarm/Shutdown

- a. Loss of excitation alarm/shutdown
- b. Instantaneous over excitation alarm/shutdown
- c. Time over excitation alarm/shutdown
- d. Rotating diode failure
- e. Loss of sensing
- f. Loss of PMG

G. Inputs and Outputs

1. **Programmable Digital Inputs.** The Controller shall include the ability to accept programmable digital input signals. The signals may be programmed for either high or low activation using programmable Normally Open or Normally Closed contacts.
2. **Programmable Relay Outputs.** The control shall include the ability to operate programmable relay output signals, integral to the controller. The output relays shall be rated for 2A @ 30VDC and consist of six (6) Form A (Normally Open) contacts and two (2) Form C (Normally Open & Normally Closed) contacts.
3. **Programmable Discrete Outputs.** The control shall include the ability to operate two (2) discrete outputs, integral to the controller, which are capable of sinking up to 300mA per input.
4. **Integrated PLC Functionality.** The panel shall allow the operator to create custom logic functions to provide additional user defined control of the generator set operation.

H. Maintenance

1. All engine, voltage regulator, control panel and accessory units shall be accessible through a single electronic service tool. The following maintenance functionality shall be integral to the generator set control:
 - a. Engine running hours display
 - b. Service maintenance interval (running hours or calendar days)
 - c. Engine crank attempt counter
 - d. Engine successful starts counter
 - e. 40 events are stored in control panel memory
 - f. Programmable cycle timer that starts and runs the generator for a predetermined time. The timer shall use 7 user-programmable sequences that are repeated in a 7-day cycle. Each sequence shall have the following programmable set points:
 - 1) Day of week
 - 2) Time of day to start
 - 3) Duration of cycle

I. Remote Communications

1. Remote Communications. The control shall include Modbus TCP communications as standard via Category 6 Ethernet cable. Two fiber optic pairs will come to the Engine Control Panel and will require Phoenix Contact FL MC 2000T ST fiber optic converter(s)

J. Local and Remote Annunciation

1. Local Annunciator (NFPA 99/110, CSA 282). Provide a local, control panel mounted, annunciator to meet the requirements of NFPA 110, Level 1.

- a. Annunciators shall be networked directly to the generator set control
- b. Local Annunciator shall include a lamp test pushbutton, alarm horn and alarm acknowledge pushbutton
- c. Provide the following individual light indications for protection and diagnostics:
 - 1) Overcrank
 - 2) Low coolant temperature
 - 3) High coolant temperature warning
 - 4) High coolant temperature shutdown
 - 5) Low oil pressure warning
 - 6) Low oil pressure shutdown
 - 7) Overspeed
 - 8) Low coolant level
 - 9) EPS supplying load
 - 10) Control switch not in auto
 - 11) High battery voltage
 - 12) Low battery voltage
 - 13) Battery charger AC failure
 - 14) Emergency stop
 - 15) Spare (or ATS Remote Start wiring failure)
 - 16) Spare (or Tier 4 SCR when applicable)

2. **Remote Annunciator** shall be provided thru SCADA system as per contract drawings.

K. The engine shall be provided with an integrally mounted instrument and control panel, vibration isolated, dead front, constructed of 14-gauge steel and containing at least the following equipment:

Coolant temperature gauge
Oil pressure gauge

Four position selector switches marked for “auto,” “manual,” “stop,” and “stop/reset.”
Automatic starting controls (2 wire start/stop)
Coolant level pre-alarm
Coolant temperature pre-alarms (low and high)
Fuel pressure pre-alarm
Low dc voltage alarm to indicate loss of charge on battery
Electrical contacts and "push to test" pilot lights for shutting down the engine on low oil pressure, high oil temperature, overcrank, high coolant temperature, and overspeed condition
Individual electrical contacts for remote indication of any pre-alarm or alarm condition
Running Time Meter (Non Resettable) to display hours and tenths
Emergency stop button
Voltmeter and switch, ammeter and switch, frequency meter

1. Provide necessary communications components required for Modbus TCP communications and provide necessary hardwired points as shown. Where I/O shown requires additional instrumentation not otherwise specified herein it shall still be included as part of this Work.
2. Generator shall have intake from end hood and exhaust air out top of the enclosure
3. Provide controls and wiring to open the inlet air damper when the generator-set is running and close the damper when the generator-set is off. The damper shall be a “power close, spring open” type, utilizing 120 volt power

L. Wiring

1. Signal wiring shall be segregated from power wiring and be arranged neatly to facilitate tracing of circuits.
2. Plastic wiring wraps shall be used to bundle wires, except within wiring ducts. The bundles shall be securely fastened to the steel structure at suitable intervals not exceeding 12-inches in length. No open space hanging of wires will be permitted. Flexible stranded copper wiring shall be used throughout. No solid conductor wire shall be permitted.
3. Terminal blocks shall be provided for interconnections between remote devices and local control panel wiring. The terminal blocks shall be factory assembled on a mounting channel, and the channel shall be bolted to the inside of the panel. The terminals shall have a continuous marking strip using the nomenclature on the schematic diagrams. No more than 2 wires shall be terminated at any one

terminal. Wire terminals shall have sleeve wire markers properly marked to match the schematic diagrams.

2.13 GENERATOR ENCLOSURE AND FUEL TANK

A. SOUND-ATTENUATED GENERATOR ENCLOSURE

1. A weatherproof, sound attenuated type enclosure of steel mounted on the fuel tank base shall be provided to house the engine/generator and accessories. The generator-set, enclosure, base-mounted fuel tank, and accessories shall be assembled and shipped to the Site as a complete, coordinated package, ready for installation. The engine generator base, cooling system, etc, shall be factory painted before installation in the enclosure.
2. The following standards and codes shall be met at a minimum:
 - a. NEPA 70 (National Electric Code)
 - b. NFPA 30
 - c. NFPA 37
 - d. NFPA 110
 - e. UL 142
 - f. API 620
3. The enclosure shall be constructed with an aluminum diamond plate finished floor for mounting on a concrete pad. The enclosure shall conform to the following design criteria:

Rigidity wind test equal to	93 MPH nominal unfactored wind loading
Roof load equal to	50 lbs.(total load)
Rain test equal to	4-inches per hour
Seismic Rating	Site Class D, Risk Category III, Seismic Design Category B, $S_{ds}=0.13G$ and $S_{d1}=0.093g$, as per Section 01612

4. Test data on similar construction by the manufacturer shall be available to the ENGINEER upon request.
5. Enclosure shall consist of a roof, steel floor, fuel tank base, 2 side walls and 2 end walls, of stressed skin, semi-monocoque construction, sized as required to meet dimensional, sound attenuation, and code requirements for the actual generator provided.
6. The system shall include a cooling and combustion air inlet silencer section, an equipment enclosure section, and a cooling air discharge silencer section. It shall be designed to reduce source noise by an estimated average 75 dB(A) as measured at a distance of 23-feet from the enclosure with the genset running

under full load.. The enclosure shall also be bird- and rodent-proof with all openings screened.

7. Enclosure Sound Attenuation: Acoustical foam shall be provided between all supports and inside doors and sound baffles on air intake and air discharge
8. Lifting provisions shall be provided at the enclosure base, with capacity suitable for rigging the entire assembly. Quality assurance procedures of the manufacturer shall include regular testing of the lift devices.
9. A minimum of 2 single personnel access doors shall be provided. Doors shall consist of an extruded frame with skin material matching enclosure. Doors shall be fully gasketed to form a weathertight perimeter seal and be padlockable. Hinges shall be stainless steel, and lock mechanisms shall be 3 point,. The door threshold, if needed, shall be aluminum. Stairs and handrails shall be aluminum and shall be manufactured to meet field-installed conditions.
10. Air handling shall be as follows: Air shall enter the enclosure through an end intake hood that points down. Motor-operated dampers shall be provided on the wall of the intake hood, wired to be spring operated to open upon engine startup. Radiator discharge shall be through a gravity-operated damper and into an exhaust plenum with top exit. The system shall not exceed 0.5-inch wg total external static pressure to ensure adequate airflow for cooling and combustion. Rain and snow entry into the plenum shall be minimized. Where rain and snow enters the plenum it shall drain from the bottom so as not to enter the generator.
11. A bolt-in-place removable end wall panel shall be provided for maintenance and/or equipment installation. Bolts, nuts, and washers shall be stainless steel.
12. Enclosure manufacturer shall provide all necessary hardware to externally mount the exhaust silencer and maintain the weatherproof integrity of the system. A bird screen shall be installed on exhaust outlet.
13. An AC electrical package shall include minimum four (4) LED outdoor lights, one nickel cadmium battery-backed emergency light with two LED heads, one light switch, and 4 duplex GFCI, weather proof receptacles. Lights and receptacles to be mounted, outdoor on each side of enclosure. These items, as well as the motor-operated air inlet damper, shall be factory wired to a AC distribution box 60A, 120/208V. Input power to the AC distribution box as indicated on the drawings.

B. FUEL SUB BASE TANK:

Provide a double wall containment, diesel fuel tank integral with the base of the generator-set and generator-set enclosure, constructed to meet specified local codes and requirements. The fuel tank shall have capacity for 48 hours' operation at full load. It shall be contained in a rupture basin with 110% capacity. The tank shall meet UL142 standards and State of Ohio fuel tank requirements. A locking fill cap, a mechanical reading fuel level gauge, low fuel level alarm shall be provided. Provide leak detection, and fuel level indication HIGH/LOW flow switches for filling in accordance with the Contract Drawing Generator P&ID including availability of all I/O required.

14. Fuel tank sensors feed back into generator controller.

2.14 SPARE PARTS

- A. Four sets of the following spare parts shall be furnished:
 - 1. Air filters
 - 2. Oil filters
 - 3. Fuel filters

PART 3 -- EXECUTION

3.1 FACTORY TESTING

- A. The generator system shall be tested at the factory before shipment to the Site. The manufacturer's standard testing procedure shall be followed, and in the event the system does not satisfy the test criteria or the requirements of this Section, it shall be repaired, modified, or replaced until it conforms.
- B. Furnish the ENGINEER two (2) weeks' prior notice of the testing date and a copy of the manufacturer's test procedure. Submit test results with the final O&M Manual.

3.2 GENERATOR SUPPLIER SERVICES DURING CONSTRUCTION - MANUFACTURER'S REPRESENTATIVE, START-UP ASSISTANCE AND TRAINING

- A. The GENERATOR SUPPLIER shall arrange for a technical representative of the manufacturer for pre-commissioning checkout of the equipment and to instruct the operating personnel in the operation, shutdown, startup, and maintenance of the equipment. Such services shall be included in the contract price for the number of days and round trip to the site as required.
- B. Manufacturers' installation supervisor shall observe, instruct and guide the CONTRACTOR's erection or installation procedures as required. The equipment manufacturer will be provided with written notification 10 days prior to the need for such services.
- C. The manufacturer's representative shall furnish on-Site start-up assistance and shall inspect the installation prior to start-up to verify that equipment is installed in accordance with the manufacturer's requirements.
- D. When required, an experienced, competent, and authorized representative of the manufacturer shall visit the site of the Work and inspect, check, adjust if necessary, set all relays in accordance with the settings designated in the coordination study, and approve the equipment installation. The representative shall be present when the equipment is placed in operation and shall revisit the jobsite as often as necessary until all trouble is corrected and the equipment installation and operation are satisfactory in the opinion of ENGINEER.
- E. Generator shall be tested at 100% KW and unity power factor (resistive load bank) at the site.
- F. The GENERATOR SUPPLIER shall furnish a written report certifying that the equipment has been properly installed and lubricated; is in accurate alignment; is free from any undue stress imposed by connecting piping or anchor bolts; and an additional report

certifying it has been operated under the stated load conditions and that it operated satisfactorily.

- G. All costs for these services shall be included in the Contract Price for the number of days and round trips to the site as needed.
- H. The CONTRACTOR will be responsible for providing fuel at the installation location. The GENERATOR SUPPLIER shall be responsible for providing fuel necessary for all factory testing.
- I. In addition, the manufacturer's representative shall provide on-Site training for operation and maintenance of all equipment included in this Section.
- J. The following times shall be included, as a minimum, for the above tasks. A Day is defined as 8 hours on-Site, exclusive of meals and travel. Each task shall be considered a separate trip to the site. Dates and times for the trips shall be coordinated with the OWNER, ENGINEER and the CONTRACTOR.
- K. Inspection of the installation: 2 Days
- L. Startup assistance: 3 Days
- M. Operation and Maintenance Training: The Manufacturers Field Service Technician shall conduct a minimum of two (2) eight-hour training sessions after system start-up and acceptance by the OWNER. Training shall include Operation and maintenance of the system.

END OF SECTION

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SECTION 26 41 23 - LIGHTNING PROTECTION SYSTEM

PART 1 -- GENERAL

1.01 DESCRIPTION

A. SCOPE

1. The CONTRACTOR, through a qualified Subcontractor, shall design and provide a lightning protection system, complete and operable, as indicated in accordance with the Contract Documents.
2. The lightning protection Subcontractor shall be certified by the Lightning Protection Institute (LPI), for both the design and the installation of the lightning protection system.
3. The system shall be installed by a Master Installer certified by LPI.
4. The system shall be inspected, at the stages of construction recommended by LPI, by a Designer/Inspector certified by LPI.
5. Qualifications for the lightning protection Subcontractor shall be submitted for approval.

B. COORDINATION

1. The CONTRACTOR shall provide coordination with other contractors and supervision of installation as needed during construction.

C. RELATED SECTIONS

1. Section 01 33 00, Submittal Procedures.
2. Section 01 60 00, Products, Materials, Equipment, and Substitutions
4. Section 26 00 10, Electrical General Requirements.
6. Section 26 00 00, Electrical Tests.
7. Section 26 04 53, Underground Raceway Systems.
8. Section 26 05 26, Grounding and Bonding for Electrical Systems

1.02 REFERENCES

- A. This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.

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Unless otherwise specified, references to documents shall mean the documents in effect at the time of the Bid Opening. If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued. Where document dates are given in the following listing, references to those documents shall mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, discontinued or replaced.

Reference	Title
NFPA 780	Standard for the Installation of Lightning Protection Systems
NFPA 70	National Electrical Code 2023
UL 96A	Lightning Protection Components
LPI-175	Lightning Protection Institute Installation Code

1.03 QUALITY ASSURANCE

- A. The lightning protection system shall be inspected and tested after installation by conducting continuity and ground resistance tests as well as a visual inspection. Inspection results and test data shall be submitted in accordance with the submittals section. The CONTRACTOR shall provide the services of an LPI Certified Inspector, independent of the system Designer, who shall inspect the system at each stage of construction recommended by LPI. This Certified Inspector shall serve as OWNER's agent during the LPI certification process. The CONTRACTOR shall furnish an LPI Certified System nameplate on each structure/building. The nameplate shall be attached to the building at a location approved by the OWNER.

1.04 SUBMITTALS

- A. The following submittals shall be provided in accordance with Section 01 33 00 – Submittal Procedures:
 1. A copy of this specification section, with addendum updates included, and all referenced and applicable sections, with addendum updates included, with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements. Check marks (✓) shall denote full compliance with a paragraph as a whole. If deviations from the specifications are indicated, and therefore requested by the CONTRACTOR, each deviation shall be underlined and denoted by a number in the margin to the right of the identified paragraph, referenced to a detailed written explanation of the reasons for requesting the deviation. The ENGINEER shall be the final authority for determining acceptability of requested deviations. The remaining portions of the paragraph not underlined will signify compliance on the part of the CONTRACTOR with the specifications. Failure to include a copy of the marked-up specification sections, along with justification(s) for any requested deviations to the specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration.
 2. Qualifications for the lightning protection Subcontractor shall be submitted for approval prior to Shop Drawings.

3. Furnish Shop Drawings in accordance with the requirements of Sections 01 33 00 – Submittal Procedures and 26 00 10 – Electrical General Requirements.

a. Products: Furnish manufacturer's catalog data for all materials.

b. Drawings

1) Furnish a scaled drawing of the facility showing the lightning protection system.

2) The drawing shall show, at a minimum:

a) The location of air terminals.

b) The routing of conductors.

c) Connections to the electrical grounding system and ground rods.

d) Details of air terminal mounting and bonding to vents, chimneys, antennas, and other metallic structures.

e) Details for roof penetrations.

3) Cross-reference the materials provided with the manufacturer's catalog numbers and cuts.

1.05 SHIPMENT, PROTECTION AND STORAGE

A. Equipment shipment, protection and storage shall conform to the requirements specified in Section 01 60 00 – Products, Materials, Equipment, and Substitutions.

1.06 WARRANTY

A. General Warranty – TBD.

PART 2 -- PRODUCTS

2.01 MANUFACTURERS

A. The system components shall be manufactured by a company that has been specializing in the manufacture of lightning protection equipment for at least 5 years and is a member of LPI.

2.02 GENERAL

A. Products shall be UL-listed for use in lightning protection systems.

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- B. Products shall be Class I for structures not greater than 75 feet high.
- C. Air terminals for aluminum roofs or structures shall be of aluminum construction.
- D. Air Terminals

1. Air terminals shall project a minimum of 10 inches above the objects protected, and shall be located at intervals not exceeding 20 feet along ridges and around the perimeter of flat roof or gently sloping roofs.
2. Flat or gently sloping roofs exceeding 50 feet in width shall be provided with additional air terminals at intervals not exceeding 50 feet on the flat or gently sloping area.
3. Locate air terminals within 24 inches of the roof edge and outside corners of the protected area.
4. Provide air terminals for metal stacks, flues, and mechanical equipment having a metal thickness of less than 3/16 inch and not within a zone of protection of an air terminal.
5. Equipment with a metal thickness 3/16 inch or greater shall be bonded in accordance with code requirements.
6. Air terminals shall be No. A71, 1/2-inch by 12-inch (or longer, as required), constructed of solid aluminum, and shall use air terminal bases of cast aluminum construction for aluminum roofs.
7. Air terminals shall be No. 71, 1/2-inch by 12-inch (or longer, as required), constructed of solid copper, and shall use air terminal bases of cast bronze construction for non-aluminum roofs.

E. Conductors

1. Structures Less than 75 Feet High

a. With Aluminum Roofs

- 1) Main size conductors on the roof shall be No. A28, Class I aluminum lightning conductor, consisting of 28 strands of 14 AWG aluminum wire weighing 115 lbs. per 1000 feet.
- 2) Secondary bonding conductors shall be No. A10, secondary bonding conductor, consisting of 10 strands of 14 AWG aluminum wire.

3) Down Conductors

- a) Down conductors shall be No. 29, Class I copper lightning conductor.

LIGHTNING PROTECTION SYSTEM

- b) Do not conceal down conductors in exterior wall construction. Provide schedule 80 PVC conduit inside building. Seal all above/below grade penetrations to be watertight. Below grade penetrations will require transition to rigid metal conduit for use with Link-Seal device per requirements of 26 05 43 – Underground Raceway Systems.
 - c) Use bimetallic connectors for the transition from aluminum roof conductors to copper down conductors.
- 4) Provide buildings over 60 feet high with a conductor counterpoise cable constructed of 29/17 copper in conformance with NFPA code requirements.
- a) With Non-Aluminum Roofs
- 5) Main size conductors on the roof shall be No. 29, Class I copper lightning conductor, consisting of 29 strands of 17 AWG copper wire weighing 190 lbs. per 1000 feet.
- 6) Secondary bonding conductors shall be No. 14, secondary bonding conductor, consisting of 14 strands of 17 AWG copper wire.

E. Miscellaneous Hardware

- 1. Provide miscellaneous hardware as may be required for the installation of the lightning protection system.
- 2. The hardware shall be compatible with the indicated air terminal and conductor materials.
- 3. Nuts, bolts, and other fasteners shall be constructed of stainless steel.

F. Corrosion Protection

- 1. Provide corrosion protection at the junctions of dissimilar metals and at locations where the components of the lightning protection system may be subjected to corrosion.
- 2. Use bimetallic connectors and fittings for splicing and bonding dissimilar metals.
- 3. Bimetallic connectors shall be located not less than 18 inches above grade.
- 4. Copper components within 24 inches of a chimney or vent emitting corrosive gases shall be protected by a hot-dipped lead coating or by another method as approved by the ENGINEER.

G. Grounding Materials

- 1. Ground rods and ground conductors shall conform to the requirements of Section 26 05 26 – Grounding.
- 2. Down conductors shall be connected to the ground rods using exothermic weld connections .

H. Structural Steel System

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1. Structural steel may not be substituted for down conductors.

PART 3 -- EXECUTION

3.01 INSTALLATION

- A. The lightning protection system shall be installed in accordance with applicable code requirements by a Subcontractor certified in the following organizations:

1. NFPA
2. LPI
3. UL

- A. Bends in conductors shall be gradual, utilizing a radius of 8-inches or greater and forming an angle of at least 90 degrees.

- B. The lightning protection system shall be installed in a neat and inconspicuous manner so all components will blend in with the appearance of the building. All conductors shall be concealed or semi-concealed during construction using methods recommended in NFPA 780.

- C. Air terminals shall have base supports designed for the surface on which they are used and shall be securely anchored. All exposed metal eave troughs, roof vents, guy wires, antennas, and air handling equipment shall be bonded to the lightning protection system in such a way that two paths to ground are provided.

- D. The lightning protection system shall be bonded to structure/building electrical ground rings wherever they are available.

E. Roof Penetrations

1. Roof penetrations shall be made using a conduit sleeve passing through a pitch pocket.
2. The CONTRACTOR shall construct the pitch pockets in such a way as to maintain the roofing warranty required under Section 07 52 16 in full force.

F. Interconnections of Metals

1. Metal bodies within 6 feet of the conductor shall be bonded to the system with approved fittings and conductor.
2. Bonding of metallic objects and systems at roof levels and elsewhere on the structure shall be complete.
3. The primary bonds for metal bodies of conductance, which shall include the following items, shall be bonded with appropriate fittings and full-size conductor:

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- a. roof exhaust fans
 - b. HVAC units with related piping ductwork
 - c. exhaust vents and other roof piping systems
 - d. cooling towers and rail systems
 - e. window-washing tracks
 - f. antenna masts for TV, radio, or microwave
 - g. flag poles
 - h. roof handrails
 - i. decorative screens
 - j. roof ladders
 - k. skylights
 - l. metal plumbing stacks
4. Exterior architectural metal fascia, curtain walls, or mullions, which extend the full height of the structure, shall be bonded, if not inherently bonded through the building frame.
5. Metal Bodies of Conductance
- a. Metal bodies of inductance located within 6 feet of a conductor or object with secondary bonds shall be bonded with secondary cable and fittings.
 - b. Typical of these are:
 - 1) roof flashings
 - 2) parapet coping
 - 3) gravel guards
 - 4) isolated metal building panels or siding
 - 5) roof drains and down spouts

6) roof insulation vents

7) other sizeable miscellaneous metal fabrications

G. Inspection and Acceptance

1. The lightning protection system shall be inspected, tested, and certified.
2. The CONTRACTOR shall retain the services of an independent inspector.
3. An LPI/UL Certificate of Inspection shall be furnished to the ENGINEER.

3.02 FIELD TESTING

- A. Testing shall conform to the requirements of Section 26 01 26 – Electrical Testing and those specified in this Section.

3.03 TRAINING -- NOT USED

END OF SECTION

SECTION 26 43 00 - SURGE PROTECTION DEVICES (SPD)

PART 1 -- GENERAL

1.1 THE SUMMARY

- A. Provide all labor, materials, equipment, and incidentals as shown, specified, and required to furnish and install surge protective devices (SPD).
- B. SPDs furnished under this Section shall be ANSI/UL 1449 Type 2 integrating both surge suppression and high-frequency noise filtering suitable for use on low-voltage distribution systems.
- C. The requirements of Section 26 00 10– Electrical General Requirements, apply to the WORK of this Section

1.2 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

- A. Reference Standards:
 - 1. ANSI/UL 1449, Fourth Edition, Safety Surge Protective Devices
 - 2. IEEE C62.41.1, Guide on the Surge Environment in Low-Voltage (1000V and Less) AC Power Circuits
 - 3. IEEE C62.45, Recommended Practice on Surge Testing for Equipment Connect to Low-Voltage (1000V and Less) AC Power Circuits
 - 4. UL 1283, Safety Electromagnetic Interference Filters
 - 5. NFPA 70, National Electric Code

1.3 CONTRACTOR SUBMITTALS

- A. Furnish submittals in accordance with Section 26 00 10 – Electrical General Requirements.
- B. Shop Drawings:
 - 1. Electrical and mechanical drawings for each type of unit, showing electrical ratings, dimensions, mounting provisions, connection details, and layout diagrams.
- C. Product Data:
 - 1. Manufacturer's technical information, including catalog information.
 - 2. Manufacturer's technical specifications with assembly and component ratings.
- D. Certifications: Certification that SPD devices comply with standards referenced in this Section.

SURGE PROTECTION DEVICES (SPD)

1.4 QUALITY ASSURANCE

A. Qualifications:

1. Manufacturer: Shall have at least five (5) years' experience manufacturing and servicing products substantially similar to those required and shall be able to submit documentation of at least 5 installations in satisfactory operation for at least five (5) years each.

B. Component Supply and Compatibility:

1. Obtain all products included in this Section regardless of component manufacturer from a single SPD manufacturer.
2. SPD manufacturer shall review and approve or prepare all Shop Drawings and other submittals for all components furnished under this Section.
3. Components shall be suitable for the specified service conditions and shall be integrated into overall assembly by SPD manufacturer.

PART 2 -- PRODUCTS

2.1 GENERAL

- A. SPD shall be modular, high-energy, parallel design with fast-acting transient voltage suppression using metal oxide varistors. Equipment shall provide noise attenuation with electromagnetic interference filter.

B. SPD shall be suitable for operation under the following environmental conditions:

1. Relative Humidity: Zero to 95%, non-condensing
2. Frequency: 47 to 63 Hz
3. Temperature: Zero to 149°F
4. SPD operating voltage shall be suitable for the associated SPD location(s).
5. SPD shall be suitable for internal and external mounting. SPD shall be factory-mounted and integrated into distribution equipment specified under the following Sections:
 - a. Section 26 00 10 – Electrical General Requirements
 - b. Section 26 11 10 – Low Voltage Switchgear
 - c. Section 26 24 16 – Panelboards
 - d. Section 26 22 00 –Low-Voltage Transformers
 - e. Section 26 29 00 – Low Voltage Motor Control Centers

- C. SPD shall include a surge suppression path for each mode as required for the system configuration. Each mode shall be individually fused and equipped with thermal cutouts.

SURGE PROTECTION DEVICES (SPD)

SPD short-circuit current rating shall be 200 kA. Protection modes shall include, to the extent applicable, the following:

1. Line-to-line

2. Line-to-neutral

3. Line-to-ground

4. Neutral-to-ground

D. SPD shall include electromagnetic interference/radio frequency interference (EMI/RFI) noise rejection filter with attenuation up to 30 dB from 10 kHz to 100 MHz.

E. SPDs and components in the operating path shall have maximum continuous operating voltage greater than 115% of nominal system operating voltage.

F. ANSI/UL 1449 minimum withstand rating shall be 20 kA per pole, and ANSI/UL 1449 voltage protection rating for SPD shall not exceed the following:

Modes	208Y/120	480Y/277
L-N,L-G, N-G	800	1200
L-L	1200	2000

G. SPD surge capacity based upon IEEE C62.41 location category shall, as a minimum, be the following:

Category	Application	Per Phase	Per Mode
C	Service entrance	240 kA	120 kA
B	High exposure locations (distribution equipment)	160 kA	80 kA
A	Branch locations	120 kA	60 kA

H. Provide SPD equipped with the following accessories:

1. Surge counter with display for indicating the number of surges detected.

2. LED indicators for monitoring device status.

3. Audible alarm and silence switch for indicating an inoperative condition.

4. Dry contacts, "form C", for remote annunciation of unit status.

I. Source Quality Control: Perform manufacturer's standard factory tests on equipment. Tests shall be in accordance with ANSI/UL 1449.

J. Manufacturers: **General Electric, Eaton, Schneider Electric/Square D Company, or equal.**

PART 3 -- EXECUTION

3.1 GENERAL

- A. Install SPD in accordance with equipment manufacturer's written recommendations and instructions and the Contract Documents.
- B. Where an SPD cannot be installed integral with the equipment to which it is connected, conductor length between suppressor and connection point shall be as short and as straight as possible.

END OF SECTION

SECTION 26 50 00 - LIGHTING

PART 1 -- GENERAL

1.1 DESCRIPTION

A. SCOPE

1. Provide luminaires and accessories, complete and operable, in accordance with the Contract Documents.

B. RELATED SECTIONS

1. Section 01 33 00, Submittal Procedures.
2. Section 01 60 00, Product Requirements.
3. Section 26 00 10, Electrical General Requirements.
4. Section 26 01 26, Electrical Tests
5. Section 26 05 15, Industrial Control Panels.

1.2 REFERENCES

- A. This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.
- B. Unless otherwise specified, references to documents shall mean the documents in effect at the time of the Bid Opening. If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued. Where document dates are given in the following listing, references to those documents shall mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, discontinued or replaced.

Reference	Title
NFPA 70	National Electric Code 2020
NEMA 250	Enclosures for Electrical Equipment (1,000 Volts Maximum)
IBC	International Building Code, Earthquake
IESNA	Illuminating Engineering Society of North America (IESNA) Publication, IESNA, Handbook 10TH edition
UL-924	Standard for Safety Emergency Lighting and Power Equipment

1.3 QUALITY ASSURANCE – not used

1.4 SUBMITTALS

C. The following submittals shall be provided in accordance with Section 01 33 00 – Submittal Procedures:

1. A copy of this specification section, with addendum updates included, and all referenced and applicable sections, with addendum updates included, with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements. Check marks (✓) shall denote full compliance with a paragraph as a whole. If deviations from the specifications are indicated, and therefore requested by the CONTRACTOR, each deviation shall be underlined and denoted by a number in the margin to the right of the identified paragraph, referenced to a detailed written explanation of the reasons for requesting the deviation. The ENGINEER shall be the final authority for determining acceptability of requested deviations. The remaining portions of the paragraph not underlined will signify compliance on the part of the CONTRACTOR with the specifications. Failure to include a copy of the marked-up specification sections, along with justification(s) for any requested deviations to the specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration.

2. Furnish the following information:

a. Interior Luminaires

- 1) Catalog data sheets and photos
- 2) Luminaire finish and metal gauge
- 3) Lens material, pattern, and thickness
- 4) Candlepower distribution curves in 2 or more planes
- 5) Candlepower chart, 0 to 90 degrees
- 6) Lumen output chart
- 7) Average maximum brightness data in foot-lamberts
- 8) Coefficients of utilization for zonal cavity calculations
- 9) Mounting or suspension details
- 10) Heat exchange and air handling data

b. Lamps

- 1) Voltages
- 2) Colors
- 3) Approximate life (in hours)
- 4) Approximate initial lumens

5) Lumen maintenance curve

1.5 SHIPMENT, PROTECTION AND STORAGE

- A. Equipment shipment, protection and storage shall conform to the requirements specified in Section 01 60 00 – Products, Materials, Equipment and Substitutions.

1.6 WARRANTY

- A. General Warranty – Refer to General Conditions.

PART 2 -- PRODUCTS

2.1 LUMINAIRES

A. MANUFACTURER

1. See Luminaire Schedule in the Contract Drawings. Provide luminaires in accordance with the classified areas as noted on drawings.

B. Indoor

LED lighting fixtures using MVOLT 120/277

C. Emergency Lighting

1. Power Pack

a. self-contained.

b. 120/277 VAC dual voltage.

c. see luminaire schedule Contract Drawing for battery voltage and type .

d. indicator switch in accordance with the requirements of UL 924.

2. lighted, push-to-test pushbutton and indicator.

3. Capability of providing full illumination for 1-1/2 hours in emergency mode.

4. Capability of full recharge in 24 hours, automatically initiated upon resumption of normal line voltage.

5. Capability of protecting against excess charging and discharging.

6. LED lamp assembly, sealed lighting heads.

7. Solid state charger.

8. Normal and emergency LED indicating lights.

9. Shall be hardwired. Power cord and plug set are not acceptable.

10. Mounting stand.

LIGHTING

11. Time delay relays in order to maintain emergency lighting in areas for 5 minutes after normal power has been restored.
12. Provide NEMA-rated enclosures in accordance with the area classifications in which they are installed.

D. Exit Signs

1. Internally illuminated
2. Universal mounting type
3. Internal 6 V sealed ni-cad, maintenance free battery
4. Battery charger
5. LED-type emergency and normal indicating lights
6. press-to-test button
7. Directional arrows
8. Red letters on a white panel

E. LED

1. Shall meet requirements of luminaire specified in the Contract Drawings Luminaire Schedule.

2.2 LED DRIVERS

- a. LED drivers shall meet requirements of luminaire schedule specified in the Contract Drawings Luminaire Schedule.
- b. AC driver - MVOLT (120-277VAC)
- c. Constant Current Regulated Power supply
- d. Internal Fusing
- e. Active Power factor correction, >0.9
- f. Low harmonic distortion, <20 amp

2.3 LIGHTING CONTROL

- A. All rooms shall be controlled by individual switches.
 1. One (1) On-Off switch at room door to control the lights.

Outdoor Building-Mounted Lighting Control

- a. Each outdoor luminaire shall have its own integral photocell. Adjust photocell as required for lights ON at dusk and OFF at dawn.
- b. Photocell shall be cadmium sulfide epoxy-coated type, shall have gasketed weather-proof sealed die-cast aluminum enclosure, shall be 120V operated with integral time delay feature (for headlights, lightning) and shall be conduit-mount type, as manufactured by Tork Model 2115, or approved equal.

PART 3 -- EXECUTION

3.1 INSTALLATION

A. LUMINAIRES

1. General

- a. Install in accordance with the manufacturer's recommendations.
- b. Provide necessary hangers, pendants, canopies, and other accessories.
- c. Provide additional ceiling bracing, hanger supports, and other reinforcements to the building and to concrete pole bases, as required to safely mount the luminaire.
- d. Install the luminaire plumb and level.
- e. The mounting heights indicated for wall-mounted or pendant-mounted luminaires are from the bottom of the luminaire to finished floor or finished grade, whichever is applicable.
- f. Install each luminaire outlet box with a galvanized stud.
- g. Install power and twist lock receptacle as called for in the Luminaire Schedule.

2. Pendant Mounting

- a. Provide swivel-type hangers and canopies to match the luminaires, unless otherwise indicated.
- b. Space single-stem hangers on continuous-row fluorescent luminaires 48 inches apart.
- c. Provide twin-stem hangers on single luminaires.

3. Unfinished Areas

- a. Locate the luminaires to avoid conflicts with other building systems and blockage of the luminaire light output.
- b. Luminaire Suspension
 - 1) Provide 3/8-inch threaded, 316 stainless steel hanger rods.
 - 2) Scissor-type hangers will not be accepted.

- c. For attachments to steel beams, provide flanged beam clips and straight or angled hangers.

C. CLEAN-UP

1. Remove labels and other markings, except the UL listing mark.
2. Wipe the luminaires inside and out in order to remove construction dust.
3. Clean the luminaire plastic lenses with an antistatic cleaner only.
4. Touch up painted surfaces of the luminaires with matching paint provided by the manufacturer.
5. Replace defective lamps at the Date of Substantial Completion.

3.2 FIELD TESTING

- A. Perform testing in accordance with Section 26 01 26 – Electrical Tests requirements

3.3 TRAINING -- not used

END OF SECTION

SECTION 26 60 00 – FIRE ALARM SYSTEM

PART 1 -- GENERAL

1.01 THE REQUIREMENT

- A. The CONTRACTOR shall submit system design and product information to the local *fire prevention agency having jurisdiction* for approval.
- B. The requirements of Section 26 00 10 - Electrical General Requirements, apply to the WORK of this Section.
- C. Each room shall contain a minimum of one (1) audible and visual notification device and smoke and heat detectors as required for sufficient coverage of the room connected to the area Fire Alarm Control Panel. Each room shall have a Fire Alarm Control Panel dry contact programmed for sending a signal to the plant SCADA system, and shall have two additional spare dry contacts.
- D. The Contract Documents show the proposed location of the Fire Alarm Control Panel. The Contract Documents also provide for the 120VAC, 60Hz power supply to this panel and wiring for dry contacts of each room alarm from the FACP to the SCADA system. All other wiring and conduit required is not shown on the Contract Drawings, but is required by this specification. Layout of the sensing and notification devices, based on detector coverage area, is the responsibility of the Fire Alarm System Supplier.
- E. The complete Fire Alarm Control Panel(s) and system shall be of a non-proprietary type.

1.02 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

A. Commercial Standards

NEC National Electrical Code; Article 760 Communication Circuits.

NFPA National Fire Protection Association; No. 72.

1.03 CONTRACTOR SUBMITTALS

- A. Furnish submittals in accordance with Section 01 33 00 – Submittal Procedures. A copy of this this specification section, with addendum updates included, and all referenced and applicable sections, with addendum updates included, with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements. Check marks (✓) shall denote full compliance with a paragraph as a whole. If deviations from the specifications are indicated, and therefore requested by the CONTRACTOR, each deviation shall be underlined and denoted by a number in the margin to the right of the identified paragraph, referenced to a detailed written explanation of the reasons for requesting the deviation. The ENGINEER shall be the final authority for determining acceptability of requested deviations. The remaining portions of the paragraph not underlined will signify compliance on the part of the CONTRACTOR with the specifications. Failure to include a copy of the marked-up specification sections, along with justification(s) for any requested deviations to the specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration.
- B. Shop Drawings
1. Block diagram showing system relationships of major components and quantities and interconnecting cable requirements.
 2. Plans showing equipment locations of all devices, raceway, and conductor requirements.
 3. Panel arrangements, equipment outlet devices, and special mounting details.
 4. Wiring diagrams showing terminal identification for field-installed wiring.
 5. Catalog literature for detectors, manual pull stations, and control panel components.
 6. Control logic, electrical schematic, and connection diagrams for the entire system.
 7. Voltage drop calculations demonstrating worst case (shall not exceed 10%).
 8. Battery calculations demonstrating 24 hours of normal operation and 5 minutes of alarm power at the end of that period.
- C. Stamp of approval: Furnish one copy of the system design and product information stamped with approval of the local fire prevention agency having jurisdiction.
- D. The CONTRACTOR shall furnish 6 copies of the operating and service manuals for the system. The manuals shall be bound in flexible binders with data therein printed or typewritten. Each manual shall include instruction necessary for proper operation of the system and shall include a complete block diagram of the system, a complete circuit diagnosis of the system, and a wiring designation schedule for each amplifier as well as other major components and a replacement parts list.
- E. Fire alarm system supplier certification of proper installation.

1.04 QUALITY ASSURANCE

- A. **Manufacturer's Qualifications:** Fire alarm system components shall be manufactured by firms regularly engaged in the production of fire alarm consoles, smoke detectors, and heat sensor units. Auxiliary equipment similar to that required for this project shall have been in satisfactory service for at least 5 years.
- B. **Installer's Qualifications:** The firm performing detailed design and installing the fire alarm system shall have had prior successful experience with fire alarm systems comparable in extent and complexity to this WORK. Submit a listing of the firm's experience if the ENGINEER requests.
- C. The CONTRACTOR shall post a typewritten notice at the fire alarm panel for the name, address, and telephone number of the firm to call when service is necessary. Notice shall be mounted in a glass-faced metal frame attached to the panel case.
- D. Operation of the fire alarm system shall be demonstrated to the ENGINEER to prove that the system operates properly and complies with these requirements.

1.05 MAINTENANCE DURING CORRECTION OF DEFECTS PERIOD

- A. The CONTRACTOR shall arrange for the installing firm to respond to trouble calls with a competent repair person at the Site within 24 hours of telephone notice; the installing firm shall also maintain a full inventory of replacement parts so that routine repairs can be completed within 24 hours.

PART 2 -- PRODUCTS

2.01 EQUIPMENT

- A. **Smoke Detector Unit:** Smoke detector units shall operate on the photoelectric principle. They should respond to a predetermined smoke density regardless of the rate of combustion, the distance between the detector and fire source, the combustible material, the temperature or velocity of the smoke, and whether the fire is in a confined or open area. Detectors shall be designed to ignore invisible airborne particles or smoke densities that are below the factory set alarm point. Compensating circuitry shall maintain stable operation under changes in temperature, humidity, and atmospheric conditions. Smoke detectors shall be **Honeywell Notifier part number FSP-851.**
- B. **Heat Detector Unit:** Heat detectors shall be of the fixed temperature type. The fixed temperature type shall react to abnormal heat condition and shall activate when it reaches its rated temperature. Actuation temperature shall be 135⁰ F. Heat detectors shall be Honeywell Notifier part number FST-851.
- C. **Combination Smoke/Heat Detector Unit:** Provide Honeywell Notifier combination smoke and heat detector part number FSP-851T
- D. **Base for Smoke, Heat, and Smoke/Heat Detectors:** Detector bases shall be Honeywell Notifier part number B210LP.

- E. **Horn & Strobe:** Horn and strobe shall be a combination horn and strobe in one unit. Whether mounted indoors or outdoors, provide all horn/strobe units with an outdoor rating. Units shall be capable of operating from 24VDC power source. Strobe shall be double flash type, 10,000 hours rated, operating temperature from -31F to 150F and provided with red dome type lens. Horn shall have about 200' range and sound level of 100dBa at 10'. Sound projector shall be provided on the horn. Provide **Honeywell Notifier outdoor horn/strobe unit, part number P2RK.**
- F. **Manual Fire Alarm Pull Station:** Provide Honeywell Notifier pull station, part number NBG12LX.
- G. **Fire Alarm Control Panel:** Fire alarm control panel shall contain alarm-receiving circuits with double zone capability. Each zone circuit shall be suitable for connection to heat detectors, smoke detectors, and combination smoke/heat detectors, as indicated. Upon receipt of an alarm, the receiving circuit shall lock into alarm and pulse its individual red zone LED, and signal the common control unit. An alarm output on a zone basis shall be supervised through an end-of-line resistor. In addition, any number of heat, smoke, or combination detectors can be added and intermixed on each 2 wire detector circuit. Initiating devices shall be able to operate on a 24 volt dc power supply integral to the fire alarm control panel. At least three dry contacts shall be provided for interlocking with two exhaust fans and input to local PLC panel for remote alarm. Fire alarm panel shall be provided with 24 VDC back-up batteries. **Provide Honeywell Notifier fire alarm control panel, part number NFS-320SYS.**
- H. **Fire Alarm Circuits:** Fire alarm circuits shall be electrically supervised so that a trouble signal shall indicate the occurrence of a single open or a single ground fault that would prevent proper alarm operation.
- I. The fire alarm control panel will be provided a single 120V, 60Hz, 1PH, 20A feed. The branch-circuit disconnect shall be marked red, locked on, and identified as a fire alarm circuit control. The control panel cover shall be marked with the identification number of the panel containing the branch circuit disconnect.

PART 3 -- - EXECUTION

3.01 INSTALLATION

- A. Fire alarm system installation shall be performed in accordance with manufacturer's written recommendations.
- B. Electrical WORK involving connections, controls, stations, etc., shall be performed in accordance with the applicable section of Division 26.
- C. All electrical enclosures, raceways and conduits shall be employed in accordance with all applicable codes and intended use and contain only those electrical circuits associated with the fire detection and control system and shall not contain any circuit that is unrelated to the system.
- D. All conductors shall be enclosed in rigid conduit as specified in 26 05 33 - Electrical Raceway Systems.

- E. Wiring shall be listed for use as required by Article 760 of the NEC. All wiring shall be of the proper size to conduct the circuit current, but shall not be smaller than #14 AWG for notification circuits and #18 AWG for signal line circuits unless otherwise specified for a given purpose. Wire that has scrapes, nicks, gouges, or crushed insulation shall not be used. The use of aluminum wire is strictly prohibited.
- F. All conduits shall be independently supported by separate hangers. Conduits must not be supported by tie wraps, electrical tape, T-Bar (suspended ceiling) suspension wires, or any other device not intended for the express purpose of fire alarm wire management.
- G. Splicing of circuits shall be kept to a minimum and are only to be found in an electrical device suited for the purpose.
- H. Wire spliced together shall have the same color insulation.
- I. Wire splices shall be made with appropriate devices suited for the purpose.
- J. All wire terminations shall be made with crimp terminals unless the devices at the termination are designed for bare wire terminations. At splice boxes, provide a terminal strip and make up wiring with crimped terminals label all terminals and wiring.
- K. All wiring shall be color coded. A consistent color code for fire alarm system conductors shall be used throughout the installation.
- L. White-colored wire shall be used exclusively for the identification of the neutral conductor of an alternating current circuit.
- M. Green-colored wire shall be used exclusively for the identification of the earth-ground conductor of an AC or DC circuit.
- N. A manufacturer's representative for the equipment specified herein shall be present at the jobsite for the frequency and minimum duration (travel time excluded) as specified below to perform the following manufacturer's services:
 - 1. Three (3) 8-hour sessions for inspection, assistance during installation and alignment, and certification of proper installation. The certificate of installation shall be submitted in accordance with the requirements of Section 01 33 00 – Submittal Procedures.
 - 2. Two (2) 8-hour sessions for assistance and witnessing of system testing by the CONTRACTOR and any required troubleshooting.
- O. CONTRACTOR shall cover detectors/devices to protect during construction.

END OF SECTION

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SECTION 26 28 16.11
ENCLOSED CIRCUIT BREAKERS

PART 1 GENERAL

1.01 SCOPE

- A. The Contractor shall furnish and install the molded case circuit breakers as specified herein and as shown on the contract drawings.

1.02 REFERENCES

- A. The molded case circuit breakers and all components shall be designed, manufactured and tested in accordance with the latest applicable standards of the following:
 - 1. UL 489 – Molded Case Circuit Breakers
 - 2. NEMA AB1 – Molded Case Circuit Breakers
 - 3. NEMA 250 – Enclosures for Electrical Equipment

1.03 SUBMITTALS

- A. The following information shall be submitted to the Engineer:
 - 1. Master drawing index
 - 2. Dimension sheet
 - 3. Accessory information
 - 4. Device ratings:
 - a. Voltage
 - b. Continuous current
 - c. Interrupting ratings
 - d. Cable terminal sizes
 - 5. Product data sheets

1.04 SUBMITTALS – FOR CONSTRUCTION

- A. The following information shall be submitted for record purposes:
 - 1. Final as-built drawings and information for items listed in Paragraph 1.03, and shall incorporate all changes made during the manufacturing process

1.05 QUALIFICATIONS

- A. The manufacturer of the assembly shall be the manufacturer of the major components within the assembly.
- B. For the equipment specified herein, the manufacturer shall be ISO 9001 or 9002 certified.
- C. The manufacturer of this equipment shall have produced similar electrical equipment for a minimum period of five (5) years. When requested by the Engineer, an acceptable list of

installations with similar equipment shall be provided demonstrating compliance with this requirement.

D. Provide Seismic tested equipment as follows:

1. The equipment and major components shall be suitable for and certified by actual seismic testing to meet all applicable seismic requirements of the latest International Building Code (IBC).
2. The Project Structural Engineer will provide site specific ground motion criteria for use by the manufacturer to establish SDS values required.
3. The IP rating of the equipment shall be 1.5
4. The Structural Engineer for the Site will evaluate the SDS values published on the Manufacturer's website to ascertain that they are "equal to" or "greater than" those required for the Project Site.
5. The following minimum mounting and installation guidelines shall be met, unless specifically modified by the above referenced standards.
 - a. The Contractor shall provide equipment anchorage details, coordinated with the equipment mounting provision, prepared and stamped by a licensed civil engineer in the state. Mounting recommendations shall be provided by the manufacturer based upon the above criteria to verify the seismic design of the equipment.
 - b. The equipment manufacturer shall certify that the equipment can withstand, that is, function following the seismic event, including both vertical and lateral required response spectra as specified in above codes.
 - c. The equipment manufacturer shall document the requirements necessary for proper seismic mounting of the equipment. Seismic qualification shall be considered achieved when the capability of the equipment, meets or exceeds the specified response spectra.

1.06 REGULATORY REQUIREMENTS

- A. Circuit breakers shall be UL listed.

1.07 DELIVERY, STORAGE AND HANDLING

- A. Equipment shall be handled and stored in accordance with manufacturer's instructions. One (1) copy of these instructions shall be included with the equipment at time of shipment.

1.08 OPERATION AND MAINTENANCE MANUALS

- A. Equipment operation and maintenance manuals shall be provided with each assembly shipped and shall include instruction leaflets, instruction bulletins and renewal parts lists where applicable, for the complete assembly and each major component.

PART 2 PRODUCTS

I

Quantity	Equipment	Enclosure Type
1	ENCLOSED CIRCUIT BREAKER, 480V, 800A, 100%, SERVICE ENTRANCE, OUTDOOR	NEMA 4X

PART 3

3.01 MANUFACTURERS

A. Eaton Electrical

B. Square D

C. or approved equal

The listing of specific manufacturers above does not imply acceptance of their products that do not meet the specified ratings, features and functions. Manufacturers listed above are not relieved from meeting these specifications in their entirety. Products in compliance with the specification and manufactured by others not named will be considered only if pre-approved by the Engineer ten (10) days prior to bid date.

3.02 MOLDED CASE PROTECTIVE DEVICES

- A. Protective devices shall be molded case circuit breakers with inverse time and instantaneous tripping characteristics .
- B. Circuit breaker shall be operated by a toggle-type handle and shall have a quick-make, quick-break over-center switching mechanism that is mechanically trip-free. Automatic tripping of the breaker shall be clearly indicated by the handle position. A push-to-trip button on the front of the circuit breaker shall provide a local manual means to exercise the trip mechanism.
- C. Circuit breaker shall have a 65 kA symmetrical interrupting capacity.
- D. Circuit breaker be service entrance and 100% rated as indicated on the drawings.
- E. Circuit breakers 800 ampere through 1200-ampere frame shall have microprocessor-based RMS sensing trip units.
 - 1. RMS-sensing, microprocessor-based, self-powered, and programmable providing adjustable long-time, short-time, instantaneous, and ground fault protection.
 - a. Short-time and ground fault trip functions shall include I^2t slopes as part of the trip unit programming function.
 - b. Provide trip indicators for long-time, short-time, instantaneous, and ground fault trip indication.
 - 2. All circuit breakers shall be provided with adjustable pick-up settings for long-time, short-time, and ground fault trips and adjustable time delay settings for long-time, short-time,

and ground fault settings. Provide all circuit breakers with adjustable and defeatable instantaneous pick-up.

3. The trip unit shall be Eaton type Digitrip RMS 310+ (used with Eaton circuit breakers) with ALSIG; MicroLogic H Series (used with Schneider/Square D circuit breakers).
- F. Circuit breaker trip units shall have an Arcflash Reduction Maintenance System that complies with NEC240.87.
 1. Maintenance mode cover control shall include:
 - a. Selector switch with lock-out/tag-out (LOTO).
 - b. Blue LED indicating light.
- G. ³Ground fault protection shall be provided where indicated.
- H. Where indicated circuit breaker shall have factory installed, Integral Surge Protective Device (SPD) rated 200kA.
 1. SPD shall be UL 1449, 4th Edition Listed/Rated.
 2. SPD shall be wired to the load side of the breaker so that opening the breaker will allow inspection/replacement of the SPD in a de-energized state.
 3. Viewing window shall be provided over integral SPD to allow viewing the status of the SPD with door closed.
- I. Outdoor mounted enclosures shall be provided with thermostatically controlled heaters. Heaters shall be operated at ½ rated voltage (240-volt heaters shall be sized and operated at 120 volts).
- J. Enclosure shall include 48W power supply and CPT for heaters and other miscellaneous.

3.03 ACCESSORIES

- A. Provide shunt trips, bell alarms and auxiliary switches as shown on the contract drawings.

3.04 ENCLOSURES

- A. Provide enclosures suitable for locations as indicated on the drawings and as described below:
 1. NEMA 4X watertight stainless steel intended for indoor or outdoor use to provide protection against windblown dust and rain, splashing rain, hose-directed water, damage from external ice formation, and corrosive agents.
- B. All enclosed circuit breakers shall have nameplates that contain a permanent record of catalog number and short-circuit interrupting rating and available short circuit.
- C. Provide handle mechanisms that are pad-lockable in the "OFF" position.

³ Note to Spec. Writer – Optional

PART 4 EXECUTION

4.01 FACTORY TESTING

- A. Standard factory tests shall be performed on the equipment under this section. All tests shall be in accordance with the latest version of NEMA and UL standards.

4.02 INSTALLATION

- A. The Contractors shall install all equipment per the manufacturer's recommendations and the contract drawings.

4.03 FIELD SETTINGS

- A. The Contractor shall perform field adjustments of the circuit breakers as required to place the equipment in final operating condition. The settings shall be in accordance with the approved protective device coordination study or as directed by the Engineer.

SECTION 27 10 00 - NETWORK CABLING

PART 1 -- GENERAL

1.1 THE REQUIREMENT

- A. The CONTRACTOR shall furnish and install fiber optic cables in accordance with the Contract Documents.

1.2 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

TIA/EIA-455	Standard Test Procedures for Fiber Optic Fibers, Cables, Transducers, Sensors, Connecting and Terminating Devices and Other Fiber Optic Components
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NEC	Article 770
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1.3 CONTRACTOR SUBMITTALS

A. Product Submittal

- 1. Samples of the fiber optic cable for review.

B. Pull Plan

- 1. Prior to installation of the fiber optic cable, a pull plan shall be developed that shows the proposed pull points, the direction of the pull and the equipment to be used during installation. Conduit lengths and bends shall be estimated and included in the pull plan (the CONTRACTOR shall verify all routes and pull distances using the pipeline plan and profile drawings provided in the appendix to these specifications and/or by field inspection). Pull tension calculations shall be performed during the development of the pull plan, and shall be included with the plan. These calculations are intended to show that appropriate planning has been conducted prior to pulling the cable. The CONTRACTOR shall make a reasonable effort to perform calculations that are as accurate as possible based on the information that is available. If an alternative cable placement method is utilized, such as cable jetting, then a plan is still required that details the procedure, the equipment setup, and a work plan. The plan shall be submitted to the ENGINEER ten days prior to installation for approval.

C. System Documentation

- 1. Document all fiber optic cable pulls using a graph which includes the following information:
 - a. Reel number.
 - b. Station from and station to.
 - c. Date and time.
 - d. Explanations for abnormalities in readings or interruptions.
 - e. Sign-off by CONTRACTOR and ENGINEER.
- 2. Testing Documentation

3. Test Procedures

a. General

- 1) All fiber optic cable test results, whether specified or at the CONTRACTOR's option, shall be transmitted to the ENGINEER for informational purposes. Test methods shall be submitted for review.
- 2) Published fiber optic cable specifications shall be submitted along with all test results.
- 3) All test submittals shall include the test date, make, model and serial number of the equipment used, fiber identification number, locations of test points, wavelength tested, and signatures of the technician that performed the tests and any witnesses to the tests.
- 4) The CONTRACTOR shall document any corrective action that was taken to pass any of the tests.
- 5) The Optical Time Domain Reflectometer (OTDR) test results shall be submitted in both printed and electronic format, and a copy of the software required to view the test results shall be supplied to the OWNER.

b. **Factory Tests:** Prior to shipping the fiber optic cable to the field, the CONTRACTOR shall submit for review by the ENGINEER, the results of the continuity (pass/fail) and fiber attenuation tests. The fiber attenuation tests shall include, as a minimum, the OTDR trace for each fiber and the attenuation of each fiber strand in dB/km.

c. **Pre-Installation Tests:** After delivery of the fiber optic cable to the site and prior to the start of the installation, the CONTRACTOR shall submit for review by the ENGINEER, the results of the fiber tests.

d. **Post-Installation Tests:** Within 14 days following the completion of the fiber optic cable installation, the CONTRACTOR shall submit for review by the ENGINEER, the results of the OTDR and fiber attenuation tests. Following is a description of the submittal requirements for each of these tests:

6) Material and Equipment

- a) A list of test equipment which will be used by the CONTRACTOR during the course of the cable testing.
- b) The manufacturer's specification sheets for each item of test equipment.
- c) The proposed testing sequence, expected duration, and scheduled date proposed for testing.
- d) Blank copies of the test forms proposed.
- e) Notification to the OWNER of any special requirements in manpower or operating conditions that need action on the part of the OWNER for the test to take place.
- f) A list of personnel who will conduct the fiber testing and a summary of their qualifications.

7) **OTDR:** The CONTRACTOR shall provide a test sheet for each fiber strand documenting the OTDR tests. This shall include, as a minimum, the OTDR trace and supplemental test data which show the overall fiber length, the distance of splice and connector points from the source, splice and connector loss, and fiber

attenuation in dB/km. The CONTRACTOR shall also submit the results of the Excess Fiber Coefficient (EFC) test.

8) Fiber Attenuation: The CONTRACTOR shall provide test documentation showing the overall end-to-end attenuation of each fiber strand at both 1310 and 850 nm and in both directions along the fiber. The CONTRACTOR shall also show that the attenuation does not exceed the maximum loss allowed.

PART 2 -- PRODUCTS

2.1 ETHERNET PATCH CABLE

A. Ethernet patch cables shall be non-plenum EIA/TIA rated category 6A and shall be compatible with patch panel and faceplate assemblies specified herein. Patch cables shall be center-tuned for optimal connection. Cables shall be snagless plug design. Provide adequate quantities to patch at field device and at network cabinet. Network cabinet cables shall be 3' length. Field equipment patch cables shall have length as necessary, but shall be 3', 7', or 15' length. Patch cables shall have a white jacket. Provide the following as required:

1. 3' cables: **Ortronics OR-MC610-03-09.**
2. 7' cables: **Ortronics OR-MC610-07-09.**
3. 15' cables: **Ortronics OR-MC610-15-09.**

2.2 ETHERNET CABLE

A. Ethernet bulk cables shall be non-plenum, Category 6A cable as per ANSI/TIA-568-C.

1. Conductor material: solid bare copper
2. Conductor size and type: 23 AWG unshielded twisted pairs
3. Number of conductor pairs: 4 (with rip cord)
4. Conductor insulation: Polyolefin
5. Jacket material: PVC
6. Impedance: 100 Ohms
7. Maximum capacitance, unbalanced: 50 pf/100m
8. UL approved
9. Product and Manufacturers: **BerkTek LanMark 2000 or approved equal.**

PART 3 -- EXECUTION

3.1 CABLE HANDLING

- A. All cable handling and storage shall be performed in strict accordance with the manufacturer's recommendation.

3.2 INSTALLATION

- A. During installation, care shall be taken not to bend the cable or innerduct excessively. Tension in the cable or the innerduct during installation shall not exceed the manufacturer's specification for tensile loading.
- B. Pulling tension shall be continuously monitored and recorded during installation. Fiber cable and the duct shall be pulled in a steady continuous manner. The bending radius of the cable or the duct shall not be exceeded.
- C. Under no circumstances shall the cable be left exposed or unattended during the installation process.
- D. The Fiber Optic Cable (FOC) shall be installed in continuous lengths without intermediate splices. The cable installation personnel shall be experienced with specific knowledge of the cable manufacturer's recommended procedures; and as a minimum shall conduct their work to conform to the following:
 - 1. The FOC's strength elements shall be properly attached to a pulling eye and 600 lb. breakaway swivel. Kellums pulling grips are not allowed except for short-length hand pulls.
 - 2. Cable tensile limits and tension monitoring devices shall not exceed cable pull tension and bend limits.
 - 3. All cable and conduits shall be continuously lubricated during the pulling procedures.
 - 4. At intermediate pull points where the fiber cable is "figure-eighted" the CONTRACTOR shall take care to insure that the cable collects a minimal amount of dust and/or dirt. If the figure-eighting of the cable is done directly on the ground, the cable shall be cleaned and re-lubricated prior to being re-pulled to the next pull point.
 - 5. Every fourth pull box/manway shall contain 100 feet of FOC coiled into a slack loop and stored in a slack enclosure.
- E. When power equipment is used to install fiber optic cables, low speeds shall be used so that a rate of 30 meters per minute is not exceeded. The tensile and bending limitation for fiber optic cables shall not be exceeded under any circumstances. Large diameter wheels, pulling sheaves, and cable guides shall be used to maintain the specified bending radius. Tension monitoring shall be accomplished using commercial dynamometers or load-cell instruments. All conduit shall be cleaned and tested prior to installation.
 - 1. All conduits shall have a lubricant applied at each conduit ingress and egress location and during the pull operation. Lubricant shall be Polywater Type F, or equal.

2. FOC shall be installed using a hydraulic capstan or winch equipped with a recording running line dynamometer graph which measures and records pulling tensions. All equipment shall be designed to prevent a preset pulling tension from being exceeded. The pulling tension setpoint shall be determined by the FOC manufacturer. If during the pulling operation excessive tension is detected, all operations shall cease and the ENGINEER shall be notified.
3. After the cables are installed and spliced, the innerduct/cable shall be secured and conduits and innerducts sealed with duct plugs. A minimum of 50 feet of FOC shall be stored at each end of one splice. Racking shall conform to the following:
 - a. Innerduct/cable shall be secured to the manway wall.
 - b. Imprinted plastic coated cloth identification/warning tags shall be securely attached to the innerduct/cable in at least two locations in each manway/pullbox.
 - c. All coiled cable shall be suitably placed into a slack enclosure to prevent damage to the cable and fibers.

3.3 CABLE ACCEPTANCE

- A. The cable installation shall not be considered acceptable if any of the criteria in the cable testing, described in the previous section, are not met. Testing requirements are summarized as follows:
 1. All pigtail splices shall have a loss no greater than 0.15 dB, as determined by either a Profile Alignment System (PAS) or Light Injection (LID) splice loss estimate, at the time the splice is made. Splices with an optical loss of greater than 0.15 dB shall be redone.
 2. Continuity is verified at both 1310 nm and 850 nm wavelengths for each fiber strand in the fiber cable.
 3. OTDR traces show no signs of abnormal characteristics when compared to the traces performed during the Factory Test prior to shipment.
 4. The measured insertion losses measured at both wavelengths and measured in both directions do not exceed the maximum values calculated as described in Subsection 3.3-D-2-d.
- B. After successfully completing the cable tests described above, the cable installation shall be subject to a physical inspection to verify the remaining fiber optic specification requirements have been met.
- C. If any test requirements are not met, the CONTRACTOR shall take immediate steps to identify the cause of the condition. If the cause is identified, the CONTRACTOR shall notify the ENGINEER in writing of its nature and provide a description of the proposed method or procedure to rectify the problem. This notification is required within seven working days after the conclusion of the testing.
- D. Contractor shall include with their Fiber Test submittals calibration documentation for the fiber test meter confirming that the meter was factory calibrated within the prior 12 months of fiber testing. Test conducted with a meter calibrated more than 12 months prior shall be invalid and tests shall be required to be conducted again with a more recently calibrated meter.

3.4 SITE ACCEPTANCE TEST

- A. After the completion of installation and testing, a walkthrough shall be performed to verify the Contract items not addressed by the fiber testing. The inspection shall be performed at a time agreeable to all parties. The final inspection checklist will include, but not be limited to the following:
1. Fiber splices shall be neatly organized.
 2. All connectors shall be capped and undamaged.
 3. All cabling shall be organized with no excessive bending.
 4. The specified amount of coiled cable shall be present in the splice cabinet. Cable entrances to the cabinets shall be secured.
 5. Unused cable shall be delivered to the OWNER.
 6. All cables shall be properly identified.
- B. Discrepancies found during the inspection of the fiber installation will be listed and provided to the CONTRACTOR in the form of a punchlist. The CONTRACTOR shall correct all punchlist items at no increase in CONTRACT time or cost. The CONTRACTOR shall inform the OWNER upon completion of the punchlist items. If the remedial actions are shown to be acceptable, system testing shall proceed.

END OF SECTION

SECTION 28 13 19 - SECURITY ACCESS AND SURVEILLANCE

PART 1 -- GENERAL

1.1 THE SUMMARY

- A. General: The CONTRACTOR shall provide closed circuit television systems (CCTV), including ethernet hardware and accessories for an operable Local Area Network (LAN) system and fiber optic and coaxial cables to CCTV equipment and devices, complete and operable, in accordance with the Contract Documents.
- B. Responsibilities
 - 1. The CONTRACTOR shall fully integrate the CCTV System through the use of a System Integrator. The System Integrator shall be a single firm, corporation, or other entity given full responsibility through the CONTRACTOR to the OWNER for implementation of the surveillance system and integration of its components. The System Integrator shall perform at least the following.
 - a. perform engineering as necessary
 - b. select system components for function and compatibility
 - c. supervise the installation and interconnection
 - d. test the system
 - e. place the system into operation
 - f. prepare technical manuals
 - g. conduct operator training classes
 - 2. Installer: The installer may be the CONTRACTOR's employee, a Subcontractor, an integrator, or a manufacturer's representative.
 - 3. Single Manufacturer: Components, fittings, and transmitters of the video system, with the exception of the cameras, shall be products of a single manufacturer.

1.2 CONTRACTOR SUBMITTALS

- A. Furnish submittals in accordance with Section 01 33 00 – Submittal Procedures.
- B. Shop Drawings and catalog data submittals shall include sufficient information for the ENGINEER to determine compliance of the proposed CCTV installation and local area network (LAN) with the Contract Documents. Grounding shall be shown on submittal drawings.
 - 1. Block diagram showing the system relationships of major components and quantities and interconnecting cable requirements.
 - 2. Plans showing equipment locations, raceway, and conductor requirements.

3. Control console and panel arrangements, equipment outlet devices, and special mounting details.
 4. Wiring diagrams showing terminal identification for field-installed wiring/cabling connections.
 5. Catalog literature with camera and monitor specifications.
- C. Technical Manual: Furnish 8 copies of operating service manuals for the system. The manuals shall be bound in flexible binders and data contained therein shall be typewritten. Each manual shall include instructions necessary for proper operation and receiving of the system, a complete circuit diagnosis of the system, and a wiring designation schedule for the surveillance system listing major components and a replacement parts list.
- 1.3 QUALITY ASSURANCE
- A. System Integrator Qualifications: The System Integrator shall have previous experience on projects of similar scope in the United States within the last 5 years. The System Integrator shall be located within 400-miles of the Site and shall be available to service the equipment as may be required within 24 hours of notice.
 - B. Equipment Manufacturer Qualifications: CCTV system components shall be manufactured by firms that are regularly engaged in the production of CCTV cameras, monitors, and auxiliary equipment similar to that required for this project and that have been in satisfactory service for at least 10 years.
 - C. Installer Qualifications: Installer shall have had prior successful installation experience with CCTV systems similar in scope to the system of this project.
 - D. Equipment shall be listed by and shall bear the label of Underwriter's Laboratories Incorporated (UL), as applicable.

1.4 SPECIAL WARRANTY REQUIREMENTS

- A. Equipment provided under this Section shall be guaranteed against defective parts and workmanship under the terms of the manufacturer's standard warranty. In no event shall the warranty cover a period of less than 2 years from date of final acceptance of the system.
- B. During the correction of defects period, the System Integrator shall service the system equipment as may be required within 24 hours of notice.

PART 2 -- PRODUCTS

2.1 GENERAL

- A. Power Input: Video system components shall be fully isolated with 24 VAC power supply unless the type is not available, in which case the component shall be the fully isolated type with power supply of 115 volts plus and minus 10 percent, 60 Hz plus and minus 5 percent.

- B. Signal Input: Inputs shall be current-regulated Video 1 Vp-p, composite, 75 ohm signal with 20 MHz analog processing bandwidth.
- C. Ambient Conditions: Video system components shall be suitable for continuous automatic on-line analysis of the indicated parameter under the conditions below.
 - 1. Equipment shall operate satisfactorily in ambient temperatures between minus 20 degrees and plus 120 degrees F or shall be provided with isothermal enclosures so that accuracies will not exceed one percent of span.

2.2 COMPONENTS

A. Camera

- 1. Camera shall be PoE+ (IEEE 802.3at) with following features:
 - a. Upto 30fps at 2688x1520
 - b. 25x optical zoom and unlimited digital zoom
 - c. Intelligent IR
 - d. IR distance upto 100m
 - e. Day and night function with removable IR filter
 - f. IP67 ingress protection
 - g. Vandal resistance
 - h. Supports two-way audio
 - i. PTZ movement
 - j. Tilt from -15 to 90 degrees
 - k. Auto focus
 - l. Motion detection
- 2. Camera shall be GeoVision model GV-TVD8710 or GeoVision model GV-SD4825-IR.

B. Camera Access Controller with Badge Reader

- 1. Camera access controller shall have a 2MP camera.
- 2. Enclosure shall be IP66 rated.
- 3. Badge reader shall have two RS485 connectors for Weigand protocol and Open Supervised Device Protocol (OSDP) badge reader communication.

4. Badge reader shall interrogate Radio-Frequency ID (RFID) badges and communicate badge credentials to the Security Access Controller for access and alarming.
5. Access controller shall be GeoVision GV-CS1320.

C. Magnetic Door Lock

1. Input power shall be 12 VDC or 24 VDC. Unit shall automatically accept either voltage with no field adjustment.
2. Environmental operating temperature shall be -40 degrees Fahrenheit to 140 degrees Fahrenheit.
3. Contractor shall provide all mounting hardware and door strike plates mounted on doors. Coordinate required bracket types with each installation to determine exact mounting bracket required.
4. Magnetic door lock shall be GeoVision GV-EL124S.

D. Time Lapse Digital Video Recorder (DVR)

1. The time-lapse digital recorder shall be built using a steel chassis with a built-in hard drive. The recorder shall include multiplexer functions that allow live and recorded images from the 4 or 10 camera inputs to be shown on the monitor in single-camera, 4 camera, 8 camera, or 10 camera displays.
2. Live video shall be viewable while recording.
3. Video compression shall produce high-resolution playback.
4. The DVR shall have a built in 2 TB hard disk for high reliability and high speed operation.
5. The DVR shall provide on-screen programming, shall be programmable without a camera connected.
6. Recording shall be able to be done continuously or at scheduled time periods.
7. The DVR shall have 5 alarm recording speeds and an alarm search feature.
8. The built in time/date generator shall have a 7 Day timer and battery backup of 30 Days in case of a power failure.
9. It shall have wire terminals for alarm in, alarm out, alarm reset, tape-end out, warning out, and one shot operation.
10. The DVR shall have a record lock feature for security and to prevent unwanted tampering.
11. The DVR shall have connectors for video, audio, camera switchers, and other video devices.

12. It shall be capable of controlling the timed switching on a sequential switcher and shall have a record review feature for instant operation check.
13. The DVR shall have 4 built-in PoE (IEEE 802.3at) ports, VGA port and HDMI ports for video output.
14. The unit shall have USB port for flash drive to import or export settings as well as back up videos.
15. This unit shall be UL listed and be provided with a rack mounting kit.
16. The recorder shall be a GeoVision model GV-SNVR0412, and shall not be a modified consumer unit.

PART 3 -- EXECUTION

3.1 INSTALLATION

- A. Post a typewritten notice at the camera and monitor station of the name, address, and telephone number of the firm to call when service is necessary. Notice shall be mounted in a metal frame attached to the camera case.
- B. After installation of the CCTV is completed, the installation shall be inspected jointly by the CONTRACTOR and the equipment manufacturer's representatives. Any problems shall be corrected, and when both are satisfied with the installation, a written certification of the installation shall be delivered to the ENGINEER. The certification shall be prepared by the manufacturers stating that CCTV communications, modules, modems, system grounds, communication networks, and other components of the CCTV system have been inspected and are installed in accordance with the manufacturer's guidelines.
- C. Operation of the CCTV system shall be demonstrated to the ENGINEER to prove that, under normal conditions, visual coverage complies with these Specifications.

3.2 CONFIGURATION

- A. General: Program, configure, start up, and test the CCTV system, recorder, modem, and Internet Video Server. The OWNER will provide the CONTRACTOR access to a Web site, an IP number for the Internet Video Server, and phone line. The CONTRACTOR shall make configurations to the Internet Video Server and modem and provide the OWNER with any settings necessary for the Internet site. The CONTRACTOR shall demonstrate remote operation of the CCTV system on 4 of the OWNER's remote PCs connected to the World Wide Web by MS-Explorer.

END OF SECTION

SECTION 31 00 00 – SITE CLEARING

PART 1 -- GENERAL

1.1 SUMMARY

- A. In its initial move onto the Site, the Contractor shall protect existing fences, houses and associated improvements, streets, and utilities downslope of construction areas from damage due to boulders, trees, or other objects dislodged during the construction process and clear, grub, strip; and regrade certain areas, in accordance with the Contract Documents. The Contractor shall also inspect the Site conditions and review maps of the Site and facilities delineating the Owner's property and right-of-way lines.
- B. Contractor shall provide all labor, materials, equipment, and incidentals required to perform all clearing and grubbing as shown and as specified herein. Contractor shall pay for all disposal fees. The Work covered by this Section consists of removing and disposing of all trees, stumps, bush, roots, shrubs, vegetation, logs, rubbish, and other objectionable material from the Site, as required to perform the Work.

PART 2 -- EXECUTION

2.1 SITE ACCESS

- A. The Contractor shall develop any necessary access to the Site, including access barriers to prohibit entry of unauthorized persons.
- B. Where existing utilities interfere with the Work, notify the utility owner and the Engineer before proceeding in accordance with the General Conditions.

2.2 CLEARING, GRUBBING, AND STRIPPING

- A. Limits of clearing and grubbing shall be all areas within the Contract limits, except as otherwise shown. Damage outside these limits caused by Contractor's operations shall be corrected at Contractor's expense.
- B. Construction areas shall be cleared of grass and weeds to at least a depth of 6-inches and cleared of structures, pavement, sidewalks, concrete or masonry debris, trees, logs, upturned stumps, loose boulders, and any other objectionable material of any kind which would interfere with the performance or completion of the Work, create a hazard to safety, or impair the subsequent usefulness of the Work, or obstruct its operation. Loose boulders within 10-feet of the top of cut lines shall be incorporated in landscaping or removed from the Site. Trees and other natural vegetation outside the actual lines of construction shall be protected from damage during construction.
- C. Within the limits of clearing, the areas below the natural ground surface shall be grubbed to a depth necessary to remove stumps, roots, buried logs, and other objectionable material. Objectionable material from the clearing and grubbing process shall be removed from the Site and wasted in approved safe locations.
- D. The entire area to be affected by construction shall be stripped to a depth of 12 inches below the existing ground contours. The stripped materials shall be stockpiled and incorporated into landscaped areas or other non-structural embankments.

- E. Stockpile topsoil in areas where it will not interfere with construction operations or existing facilities. Stockpiled topsoil shall be reasonably free of mineral subsoil, debris, and stones larger than two inches in diameter.
- F. Unless otherwise indicated, native trees larger than 3-inches in diameter at the base shall not be removed without the Engineer's approval. The removal of any trees, shrubs, fences, or other improvements outside of rights-of-way, if necessary for the Contractor's choice of means and methods, shall be arranged with the owner of the property, and shall be removed and replaced, as part of the Work.
- G. Burning on-site shall not be performed.
- H. In order to avoid additional removal or damage, existing trees and shrubs shall be trimmed as required. Trimmed or damaged trees shall be treated and repaired by persons with experience in this specialty that are approved by Engineer. Trees and shrubs intended to remain, that are damaged beyond repair or removed, shall be replaced by Contractor, at no additional cost to the Owner.
- I. Control air pollution caused by dust and dirt and comply with governing regulations.

2.3 OVEREXCAVATION, REGRADING, AND BACKFILL UNDER FILL AREAS

- A. After the fill areas have been cleared, grubbed, and excavated, the areas to receive fill will require overexcavation, regrading, and backfill, consisting of the removal and/or stockpiling of undesirable soils. The ground surface shall be recontoured for keying the fill and removing severe or abrupt changes in the topography of the Site. Overexcavated volumes shall be backfilled to a level 12 inches below the existing ground contours.

2.4 PROTECTION OF EXISTING TREES

A. GENERAL

- 1. Flagging of Existing Trees: Flag trees to remain and to be removed with a bright and different colored ribbon. Notify the Engineer at least 48 hours prior to commencing of Work to verify all trees that are flagged.
- 2. Do not park any vehicles or equipment, nor store any materials or stockpiled soil, nor dispose of building materials, chemicals, petroleum products or other detrimental substances within drip line of tree. Protect trees from flame, smoke and heat. Construction access to site shall not occur beneath drip line of trees.

B. EXISTING TREES TO REMAIN

- 1. Protect root systems from smothering. Restrict foot traffic to prevent excessive compaction of soil over root systems.
- 2. Individual trees and areas shown to remain shall be protected by six (6) foot high chain link fence. Install fencing before site preparation, grading and clearing and grubbing operations.
- 3. Under no circumstances shall the Contractor remove existing trees designated to remain for his/her convenience or ease of construction.

4. Prior to installation, stake the location of protection fencing for approval by the Engineer. Location stakes or marking shall be placed not greater than ten (10) feet on-center.

C. EXCAVATION AROUND TREES

1. Excavate within drip line of trees only where shown.
2. Where trenching for utilities is required within drip line, tunnel under or around roots by hand digging. Do not cut main lateral roots or tap roots. The Contractor shall notify the Engineer prior to cutting roots over 6-inch diameter. Roots up to and including 3/4-inch shall be cut by hand saws. Do not leave roots exposed to sun or drying for more than 24 hours. Protect all exposed roots with moist organic mulch or burlap and backfill as soon as possible.
3. Where excavating for new construction is required within drip line of tree, excavate by hand to minimize damage to roots and perform as follows:
 - a. Use narrow tine spading forks and comb soil to expose roots.
 - b. If main lateral roots are immediately adjacent to location of new construction, cut roots three (3) inches from new construction.
 - c. Do not allow exposed roots to dry out before permanent backfill is placed.
 - d. Provide temporary earth cover, or pack with peat moss and wrap with burlap.
 - e. Water and maintain in moist condition until covered with backfill.

D. TRIMMING OF EXISTING TREES

1. Engage a qualified tree surgeon to remove branches from tree. No pruning unless approved and directed by the Engineer.
2. Pruning: Cut branches with sharp pruning instruments and do not break or chop. Prune flush with trunk surface.
3. Trimming: Symmetry of the tree shall be preserved; no stubs or splits or torn branches left; clean cuts shall be made close to the trunk or large branch. Spikes shall not be used for climbing live trees. All cuts over 1-1/2-inches in diameter shall be coated with an asphaltic emulsion material.

END OF SECTION

SECTION 31 05 19 – GEOTEXTILES

PART 1 -- GENERAL

1.1 SUMMARY

- A. The work of this Section includes furnishing and installing non-woven and woven geotextiles for construction of water conveyance systems in trench, shaft, and tunnel excavations.
- B. Install geotextile in locations shown on the Drawings, and where specified in other Sections.

1.2 REFERENCE STANDARDS

- A. ASTM D3786 Standard Test Method for Bursting Strength of Textile Fabrics—Diaphragm Bursting Strength Tester Method
- B. ASTM D4355 Standard Test Method for Deterioration of Geotextiles by Exposure to Light, Moisture, and Heat in a Xenon Arc-Type Apparatus
- C. ASTM D4491 Standard Test Methods for Water Permeability of Geotextiles by Permittivity
- D. ASTM D4533 Standard Test Method for Trapezoid Tearing Strength of Geotextiles
- E. ASTM D4595 Standard Test Method for Tensile Properties of Geotextiles by Wide-Width Strip Method
- F. ASTM D4632 Standard Test Method for Grab Breaking Load and Elongation of Geotextiles
- G. ASTM D4751 Standard Test Methods for Determining Apparent Opening Size of a Geotextile
- H. ASTM D4873 Standard Guide for Identification, Storage, and Handling of Geosynthetic Rolls and Samples
- I. ASTM D5261 Standard Test Method for Measuring Mass per Unit Area of Geotextiles
- J. ASTM D6241 Standard Test Method for Measuring Static Puncture Strength of Geotextiles and Geosynthetic-Related Products Using a 50-mm Probe

1.3 ACTION SUBMITTALS

- A. Provide manufacturer's material specifications and product literature, including recommended handling and installation procedures, for each proposed product.
- B. Provide manufacturer's certifications that geotextiles satisfy material requirements.
- C. Provide geotextile samples of each type. Label each with brand name and product identifier.

1.4 DELIVERY, STORAGE, AND HANDLING

- A. Ship, handle and store products in conformance with the manufacturer's recommendation, to maintain the product in undamaged condition.
- B. Do not store products directly on ground. Store geotextile in a way that protects it from elements. If stored outdoors, elevate and protect geotextile with waterproof cover.

PART 2 -- PRODUCTS

2.1 GEOTEXTILES – GENERAL REQUIREMENTS

- A. Fibers used in the manufacture of geotextiles, and the threads used in joining geotextiles by sewing, shall consist of long-chain synthetic polymers composed of at least 95% by weight of polyolefins or polyesters.
- B. Nonwoven geotextile shall be composed of fibers interlaced to form a planar structure with uniform random fiber pattern.
- C. Woven geotextile shall be composed of a pervious sheet of yarn interlaced to form a planar structure with uniform weave pattern. Products shall be calendared or finished so that yarns will retain their relative position with respect to each other.
- D. Rolls of geotextile shall be labeled on the roll or packaging, with manufacturer's name, product identification, roll number, and roll dimensions, in conformance with ASTM D4873.
- E. Rolls shall be wrapped with a material that will protect the geotextile, including the ends of the roll, from damage during shipping, handling, and storage.

2.2 GEOTEXTILE FOR SUBGRADE-BASE SEPARATION

- A. Geotextile for subgrade-base separation shall be used as shown on the Drawings or as directed by the Owner to prevent very soft or loose subgrade from migrating into a coarse aggregate base.
- B. Geotextile for subgrade-base separation for common application shall be nonwoven geotextile conforming to the following minimum average roll values (MARV):

Property	Requirement	ASTM Test Method
Weight	6.0 oz/sy	D5261
Grab Tensile Strength	160 lbs	D4632
Elongation	50%	D4632
Trapezoidal Tear Strength	60 lbs	D4533
CBR Puncture Strength	410 lbs	D6241
Apparent Opening Size	0.212 mm	D4751
Permittivity	1.5 sec ⁻¹	D4491
UV Resistance (at 500 hours)	70%	D4355

- C. Separation fabric shall be Mirafi® 160N by TenCate Geosynthetics; GEOTEX 601 by Propex; NW6 by GSE; or equal.

GEOTEXTILES

2.3 GEOTEXTILE FOR TRENCH SUBGRADE STABILIZATION

- A. Geotextile for stabilizing trench subgrade shall be used as shown on the Drawings or as directed by the Owner to reinforce an excavation bottom in very weak soils, while also performing a subgrade-base separation function.
- B. Geotextile for stabilizing trench subgrade shall be high-tensile strength multifilament woven geotextile conforming to the following minimum average roll values (MARV):

Property	Requirement	ASTM Test Method
Weight	8.8 oz/sy	D5261
Grab Tensile Strength	400 x 250 lbs	D4632
Wide Width Tensile Str. (2% strain)	480 x 420 lbs/ft	D4595
Trapezoidal Tear Strength	170 x 120 lbs	D4533
CBR Puncture Resistance	1,300 lbs	D6241
Apparent Opening Size	≤ 0.6 mm	D4751
Permittivity	0.5 sec ⁻¹	D4491
Water Flow Rate	40 gpm/ft ²	D4491
UV Resistance (at 500 hours)	80%	D4355

- C. Fabric shall be Mirafi® HP370 by TenCate Geosynthetics; GEOTEX 3x3HF by Propex; WINfab 3x3HF by Willacoochee Industrial Fabrics, Inc.; or equal.

2.4 GEOTEXTILE FOR CLASS 2 SUBGRADE-BASE SEPARATION IN ROAD CONSTRUCTION

- A. Geotextile for Class 2 separation application in new road construction shall be high-tensile strength woven geotextile conforming to the following minimum average roll values (MARV):

Property	Requirement	ASTM Test Method
Weight	9.9 oz/sy	D5261
Grab Tensile Strength	250 lbs	D4632
Elongation	50%	D4632
Trapezoidal Tear Strength	90 lbs	D4533
CBR Puncture Strength	700 lbs	D6241
Burst Strength	400 psi	D3786
Apparent Opening Size	≤ 0.6 mm	D4751
Permittivity	0.02 sec ⁻¹	D4491
UV Resistance (at 500 hours)	50%	D4355

- B. Stabilization fabric shall be Mirafi® 1100N by TenCate; GEOTEX 1001 by Propex; NW10 by GSE; or equal.

GEOTEXTILES

PART 3 -- EXECUTION

3.1 INSTALLATION

- A. Install geotextile in conformance with the manufacturer's recommendations for the specific application. Lay and maintain geotextile smooth and free of tension, folds, wrinkles, or creases.
- B. Cut fabric to proper width prior to installation. Provide 12-inch minimum overlap at joints.
- C. Using anchors or weights, secure fabric to excavation bottom and sides to prevent wrinkles, folding, and tearing of the fabric during placement of backfill.
- D. If tears, punctures, or other geotextile damage occurs during backfilling, remove overlying materials as necessary to expose damaged geotextile. Repair damage as indicated below.
- E. Geotextile shall not be exposed to precipitation prior to being installed, to the elements for more than 10 days after installation, or to construction traffic capable of displacing or damaging the geotextile after installation.

3.2 INSTALLING SUBGRADE-BASE SEPARATION

- A. Place geotextile as a barrier to prevent infiltration of fines into foundation stabilization or bedding material.
- B. In trench excavation, place geotextile in a way that will envelope bottom and sides of granular stabilization material or bedding material. Place geotextile with sufficient slack to contact trench bottom and sides fully when trench is backfilled.

3.3 INSTALLING ON ROADWAYS

- A. Lay the geotextile smooth without wrinkles or folds on the prepared subgrade in the direction of construction traffic.
- B. Where seams are required, seam strength shall be at least 90 percent of specified grab strength per ASTM D4632.
- C. Place subbase by end dumping onto the geotextile, or over previously placed subbase aggregate so that at least the specified lift thickness shall be always between construction equipment tires or tracks and the geotextile.
- D. If necessary, staple or pin geotextile at overlaps to maintain position during construction.

3.4 REPAIRING GEOTEXTILE

- A. Repair or replace torn, punctured, flawed, deteriorated, or otherwise damaged geotextile. Repair by placing patch of undamaged geotextile over damaged area plus at least 18 inches in all directions beyond damaged area. Remove interfering material as necessary to expose damaged geotextile for repair.

-END OF SECTION-

SECTION 31 20 00 - EARTHWORK

PART 1 -- GENERAL

1.1 SUMMARY

- A. This Section includes backfill material and compaction requirements for trench and minor structure excavations, shaft excavations, embankments, and fills.
- B. This Section also includes shallow excavations not requiring initial ground support systems such as for shallow footings, slabs-on-grade, pavements and the like.
- C. Fill materials for road base, landscaping, and other surface finishes are specified in other sections.

1.2 REFERENCE STANDARDS

- A. AASHTO T291 Standard Method of Test for Determining Water-Soluble Chloride Ion Content in Soil
- B. ASTM C33 Standard Specification for Concrete Aggregates
- C. ASTM D75 Standard Practice for Sampling Aggregates
- D. ASTM D698 Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft³)
- E. ASTM D1556 Standard Test Method for Density and Unit Weight of Soil in Place by Sand-Cone Method
- F. ASTM D2419 Standard Test Method for Sand Equivalent Value of Soils and Fine Aggregate
- G. ASTM D2487 Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System)
- H. ASTM D3740 Standard Practice for Minimum Requirements for Agencies Engaged in Testing and/or Inspection of Soil and Rock as Used in Engineering Design and Construction
- I. ASTM D4253 Standard Test Methods for Maximum Index Density and Unit Weight of Soils Using a Vibratory Table
- J. ASTM D4254 Standard Test Methods for Minimum Index Density and Unit Weight of Soils and Calculation of Relative Density
- K. ASTM D6913 Standard Test Methods for Particle-Size Distribution (Gradation) of Soils Using Sieve Analysis
- L. ASTM D6938 Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)

EARTHWORK

M. OSHA 29 CFR US Department of Labor, Occupational Safety and Health Administration, Code of Federal Regulations Title 29 Labor

N. ODOT Construction and Materials Specifications

1.3 ACTION SUBMITTALS

- A. Submit qualifications of commercial testing laboratory responsible for gradation testing.
- B. Submit samples, certifications, and specified test results of imported bedding and backfill materials.
- C. Submit an excavation, backfilling, and filling plan relating to access, maintenance of existing facilities and proper utilization of the site. Provide types and sizes of equipment proposed to perform excavation and compaction.

1.4 INFORMATIONAL SUBMITTALS


- A. Submit results of all specified field testing.

1.5 QUALIFICATIONS

- A. Commercial testing laboratory shall conform to ASTM D3740.

PART 2 -- PRODUCTS

2.1 PIPE ZONE BACKFILL - GENERAL REQUIREMENTS

- A. Pipe zone backfill shall conform to either of the following material quality requirements, subject to the limitations of the article Unsuitable Materials, below:
 - 1. ASTM C33 limits for deleterious substances and physical property requirements, Class 2N
 - 2. Ohio Dept. Transportation (ODOT) Construction and Material Specifications Section 703.11 
- B. Gradation requirements in this section are broadly stated to provide the Contractor flexibility in selecting backfill materials. However, the Contractor is solely responsible for selecting materials and gradations suited to purpose, including compatibility with pipe material and diameter, suitability for placement in confined spaces, and uniformity of compaction characteristics.
- C. Coarse, open-graded gravel shall not be placed in direct contact with fine grained soils susceptible to migrating into the backfill under the action of groundwater. Soils susceptible to migration include silt, fine sand, and soft clay or organic clay. Open-graded gravel may be used if separated from fine grained soils by an appropriate filter of sand or geotextile.
- D. Backfill materials shall be used in accordance with the following schedule:

EARTHWORK

Application	Material
trench zone - in areas where settlement must be held to a minimum	CLSM or structural backfill
trench zone - in areas where minor settlement will not adversely affect the excavated area, or CLSM or structural backfill are not required	earth backfill
pipe zone	as specified for pipe material
structure base	structural backfill
utilities exposed by excavation or trenching	CLSM, structural backfill, or sand

2.2 UNSUITABLE MATERIALS

- A. The following materials shall not be permitted in backfill of any type, including fill materials otherwise conforming to DOT specifications:
1. Soils classified under ASTM D2487 as Pt, OH, CH, MH, or OL.
 2. Soils that cannot be compacted sufficiently to achieve the density specified for their intended use.
 3. Soils containing any material which may be classified as hazardous or toxic according to applicable regulations.
 4. Soils containing concentrations of chloride or sulfate ions greater than, or having a soil resistivity or pH less than, soils in place.
 5. Frozen ground.
 6. Crushed concrete, reclaimed asphalt concrete, lightweight aggregate, or steel slag aggregate,

2.3 PIPE ZONE BACKFILL - PLASTIC PIPE

- A. Pipe zone backfill for plastic pipe shall conform to the following:
1. ASTM C33 coarse aggregate gradations 5 through 7, for pipe diameter over 15 inches
 2. ASTM C33 coarse aggregate gradations 6 through 7, for pipe diameters from 8 to 15 inches
 3. Coarse aggregate gradations may be mixed with up to 30% sand to minimize migration of fines into backfill.
 4. ASTM D2487 soil classification GW or GP, with 100% passing the 1-inch sieve
 5. ASTM D2487 soil classification SW or SP, with no more than 65% passing the No. 4 sieve

2.4 PIPE ZONE BACKFILL - STEEL OR DUCTILE IRON PIPE

- A. Pipe zone backfill for concrete pipe shall conform to:
1. ASTM C33 coarse aggregate gradations 3 through 57; may be mixed with up to 30% sand to minimize migration of fines into backfill
 2. ASTM D2487 soil classifications GW or GP, with 100% passing the 1-inch sieve

2.5 SAND BACKFILL

- A. Sand mixed with coarse aggregate shall conform to the following gradation:

Sieve	Percent Passing
9.5 mm (3/8-in.)	100
1.18 mm (No. 16)	50 to 85
150 µm (No. 100)	0 to 10

2.6 TRENCH ZONE BACKFILL

- A. CLSM or structural backfill shall be used in the trench zone in areas where settlement must be held to a minimum, including within the public right-of-way, under existing and future paved roadways and within 2 feet of pavement edge, and in paved parking areas.
- B. Earth backfill may be used in the trench zone in areas where minor settlement will not adversely affect the function, appearance, or value of the area, or where CLSM or structural backfill are not specified or shown on the Drawings, including off-road areas, parks, and undeveloped lands.

2.7 CLSM BACKFILL

- A. CLSM backfill shall conform to Section 03 34 00 Controlled Low Strength Material.

2.8 STRUCTURAL BACKFILL

- A. Structural backfill shall be used to construct a firm level base on which to construct precast or cast-in-place concrete structures, to backfill excavations around structures, and to replace compressible, soft, unstable, or otherwise unsuitable soils in the bottom of the excavation.
- B. Structural backfill shall conform to
1. ASTM C33 coarse aggregate gradations 3 through 7, but shall be mixed with up to 30% sand to minimize migration of fines into backfill.
 2. ASTM D2487 soil classifications GW or GP, with 100% passing the 1-inch sieve
 3. ASTM D2487 soil classifications SW or SP, with no more than 65% passing the No. 4 sieve

2.9 EARTH BACKFILL

- A. Earth backfill shall consist of soil, loam, or other excavated materials that are suitable for use as backfill. Earth backfill shall not include organic material, refuse, or construction debris; rock, portland concrete, asphalt concrete, or other consolidated masses larger than 1/2 cubic foot; or unsuitable material as defined in this Section.

2.10 RAPID DRAINING MATERIAL

- A. Where a Drainage Layer is shown on the Drawings, the gradation shall conform to the following:

Sieve Opening (mm)	Sieve Designation	Percent Passing
38	1-1/2 in.	100
25	1 in.	70-100
19	3/4 in.	55-100
12.5	1/2 in.	40-80
9.5	3/8 in.	30-65
4.75	No. 4	10-50
2.4	No. 8	0-25
1.2	No. 16	0-5

2.11 SOURCE QUALITY CONTROL

- A. Granular material approval shall be based on the results of gradation tests performed by a commercial testing laboratory.
- B. Sample the aggregate source in accordance with ASTM D75.
- C. Unless otherwise specified, perform material testing at a minimum frequency of three per source. Repeat for every 5,000 cubic yards of material used, and whenever visual inspection indicates a change in material gradation as determined by the Owner. Provide test results to the Owner within 48 hours after sampling.
- D. Testing procedures:
1. Gradation analysis - Perform gradation tests in accordance with ASTM D6913. Perform additional tests for each moisture-density test or maximum-minimum density test.
 2. Moisture-density relationship - Perform compaction tests in accordance with ASTM D698, using a method appropriate to material gradation. Excludes screened gravel and crushed stone.
 3. Maximum and minimum density - Perform density tests to determine maximum and minimum density of granular materials with less than 10 percent fines content, in accordance with ASTM D4253 and D4254.

4. Liquid limit, plastic limit and plasticity index - Perform limits testing in accordance with ASTM D2487. Perform on earth backfill and whenever classification of material is in doubt as determined by the Owner.
5. Sand equivalent value – Perform in accordance with ASTM D2419.
6. Testing for chloride - Perform in accordance with AASHTO T291.

2.12 ENVIRONMENTALLY CONTAMINATED MATERIAL

- A. Excavated material containing solid waste, petroleum contaminants, or special waste shall not be used as backfill unless testing is performed and the material is approved by the Owner.

PART 3 -- EXECUTION

3.1 CLASSIFICATION OF EXCAVATION

- A. Common excavation is defined as the removal of material not classified as rock excavation. Common excavation includes excavation of soil, known pavements, abandoned pipe and manholes, abandoned utilities, and the like; building debris and consolidated masses smaller than 1 cubic yard, such as concrete rubble and boulders; and highly weathered bedrock.
- B. Rock excavation is defined as the systematic use of rock breakers, or the use of equipment specifically designed for rock excavation, to excavate a full face of material which cannot be effectively excavated by other means. The term is intended to define the type of conditions normally found below the bedrock surface, but is not constrained by geologic designations.
- C. Removal of random consolidated masses larger than 1 cubic yard will be classified as rock excavation, if breaking them apart with power-operated hammer, hydraulic rock breaker, expansive compounds, or other similar means is both necessary and actually used for their removal.
- D. Notify the Owner immediately when a change in classification occurs in the heading, to allow the Owner to verify the change for payment purposes.

3.2 GENERAL REQUIREMENTS FOR EXCAVATION

- A. Control loss of soil into the excavation to prevent damage to adjacent structures and utilities, to maintain stability of the excavation sides and bottom, and to preserve the original strength of soils surrounding the excavation.
- B. In the event that ground losses during excavation cause damage or threaten to damage structures or utilities, cease excavation and modify equipment and methods to reduce ground movements.
- C. Allow no cobbles, bedrock, or unyielding debris to project within 8 inches of pipe or structure.

- D. Where excavation exposes existing utilities, replace any bedding in a manner to restore the original grade and level of support of the pipe or conduit. Complete the backfill above the existing pipeline or conduit with the backfill shown or specified, or as directed by the Owner.

3.3 CONTROL OF WATER

- A. Conform to Section 31 23 19 Control of Water, and the following additional requirements.
- B. Maintain the water table below the bottom of the excavation sufficiently to ensure a firm working surface, a minimum of 2 feet in sands and 3 feet in silts.

3.4 FOUNDATION STABILIZATION

- A. Where the existing material in the bottom of the excavation is incapable of supporting the structure, over-excavate and remove the unsuitable material, as approved by the Owner. Backfill with structural backfill over the full width of the excavation, to the required bottom grade.
- B. Structural backfill of coarse, open-graded gravel shall not be placed in direct contact with wet silts or fine sands, or clays of compressive strength less than 1 tsf. Separate these soils from structural backfill with geotextile for subgrade-base separation, as specified in Section 31 05 19 Geotextiles.
- C. Spread structural backfill in uniform, loose lifts not to exceed 8 inches. Vibrate or tamp to maximize stability of the material and to maintain uniform grade, applying at least two passes of compactive effort. Vibrate using a vibratory plate compactor, or tamp using the excavator bucket.

3.5 BACKFILL PLACEMENT AND COMPACTION

- A. Select compaction equipment that is suited to the material being compacted, and is consistently capable of achieving specified densities. Lift thicknesses shall not exceed the capabilities of compaction equipment.
- B. Compaction requirements for coarse granular materials with less than 10 percent passing the No. 4 sieve shall be by relative density in accordance with ASTM D4253 and D4254.
- C. Compaction requirements for material with 10 percent or more passing a No. 4 sieve shall be by maximum dry density in accordance with ASTM D698. Moisture content shall be brought to within 2 percent of optimum before spreading.
- D. Permanent backfill shall be protected from freezing.
- E. Backfill compaction shall conform to the following requirements:

Location or Use of Fill or Backfill	Max Dry Density (%)	Max Relative Dry Density (%)	Max Loose Lift (inches)
structural backfill - where settlements must be held to a minimum	95	85	8
earth backfill - where minor settlement can be tolerated	90	75	10
pipe zone	85	70	8
rapid draining material	95	85	10

3.6 FIELD QUALITY CONTROL

- A. Material testing minimum frequency for field density and moisture content:
 1. Trenches under structures or roadways: Every 200 lin. ft. per lift.
 2. Trenches in areas without structures or roadways: Every 1000 lin. ft. per alternate lift.
 3. Paved Areas: 3,500 sq. ft. per lift.
 4. Under Structure: 1,000 sq. ft. per lift.
 5. Around Structure: 1,500 sq. ft. per lift.
 6. Embankment Fill: 10,000 sq. ft. per lift.
- B. Field density in-place tests will be performed in accordance with ASTM D1556 (sand-cone method), ASTM D6938 (nuclear methods), or by such other means acceptable to the Owner.
- C. Backfilling and filling operation shall be suspended in areas where tests are being made until tests are completed and the testing laboratory has advised the Owner that adequate densities are obtained.
- D. In case the test of the fill or backfill shows non-compliance with the required density, the Contractor shall accomplish such remedy as may be required to ensure compliance. Subsequent testing to show compliance shall be by a testing laboratory selected by the Owner and paid by the Contractor.

3.7 MANAGEMENT AND DISPOSAL OF EXCAVATED MATERIAL

- A. The Contractor is responsible for temporary storage, transport, and disposal of excess excavated material, in accordance with permitting requirements.
- B. Material shall be disposed of at an approved on-site disposal area, or an off-site disposal location arranged by the Contractor in accordance with regulations regarding the disposal of such material.

- END OF SECTION -

EARTHWORK

SECTION 31 23 16 – TRENCH AND MINOR STRUCTURE EXCAVATION

PART 1 -- GENERAL

1.1 SUMMARY

- A. The work specified in this Section includes excavation and ground support in soil and rock to depths less than 20 feet, for pipe laying and for construction of manholes and miscellaneous concrete structures.
- B. Pipe to be installed under this Section is specified in other Sections. See the appropriate Section on pipe for any additional requirements for laying and jointing pipe, specific to the pipe material being used.

1.2 DEFINITIONS

- A. Definitions of terms in OSHA 29 CFR, Subpart P—Excavations, 1926.650(b), in its entirety, shall apply to this Section.

1.3 REFERENCE STANDARDS

- A. OSHA 29 CFR US Department of Labor, Occupational Safety and Health Administration, Code of Federal Regulations Title 29 Labor

1.4 ACTION SUBMITTALS

- A. Submit qualifications of professional engineer and “competent person” to be involved in the design and installation of protective systems.
- B. Submit drawings, computations, and supporting information describing protective systems.
 - 1. For all protective systems, submit shop drawings of designs, signed and sealed by the originator.
 - 2. For benching protective systems, submit maximum allowable slopes.
 - 3. For shield protective systems, submit:
 - a. excavation dimensions
 - b. plan indicating the sizes, types, and configurations of structural components
 - c. connection details where shields are to be stacked
 - d. specifications, limitations, and tabulated depth ratings issued by the shield manufacturer (where applicable)
 - 4. For ground support systems, submit:

TRENCH EXCAVATION

- a. ground loading conditions for design
 - b. plan indicating the sizes, types, and configurations of structural components
 - c. maximum allowable spacing between compression members
 - d. specifications, limitations, and loading capacities issued by the shoring manufacturer (where applicable)
- C. Submit the Trench Excavation Plan, including methods of excavation, protection, and groundwater control.

1.5 QUALIFICATIONS

- A. Protective systems designs shall be prepared by a registered professional engineer licensed in the U.S.
- B. Persons named as the “competent person” shall be capable of identifying excavation hazards and authorized to take corrective measures to eliminate them.

PART 2 -- PRODUCTS

2.1 BACKFILL

- A. Backfill material, compaction, and testing requirements are specified in Section 31 20 00 Earthwork.

2.2 PIPES, MANHOLES AND VAULTS

- A. Pipe shall be as specified in Section 33 92 20 Ductile Iron and Piping , Section 33 05 31 Polyvinyl Chloride Gravity Sewer Pipe and 33 11 00 Copper Process Pipe and Tubing
- B. Manholes and vaults shall be as specified in Section 33 05 62 Precast Concrete Manholes and Vaults

PART 3 -- EXECUTION

3.1 CLASSIFICATION OF EXCAVATION

- A. Excavation is classified in Section 31 20 00 Earthwork.

3.2 PROTECTIVE SYSTEMS FOR EXCAVATIONS

- A. Protective systems for trench excavation shall conform to OSHA 29 CFR Subpart P, section 1926.652.
- B. Contractor shall select protective systems or design initial support systems suited to ground conditions described in the Geotechnical Baseline Report.

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- C. Portable shield systems including “trench boxes” or “trench shields” shall not be used in cohesionless soils (such as silts and sands) below the water table.
- D. Initial support systems consisting of [interlocked steel sheeting] [timber sheeting] or comparable systems installed in advance of excavation are required in specific locations as shown on the Drawings.

3.3 GENERAL REQUIREMENTS FOR EXCAVATION

- A. Control ground losses into the excavation as necessary to prevent settlement damage to adjacent structures and utilities, maintain stability of the excavation sides and bottom, and preserve the strength of soils surrounding the excavation. Adapt the support system to variations in ground conditions as they are exposed in the excavation.
- B. As excavation progresses, perform frequent inspections for indications of settlement such as surface cracking and subsidence along the excavation perimeter, and excessive deflection or failure of support system elements.
- C. Stockpiling of excavated spoils alongside the trench or excavation, within a distance equal to the depth of excavation, is prohibited.
- D. Allow no cobbles, bedrock, or unyielding debris to project within 8 inches of pipe or structure.
- E. In the event that ground losses during excavation cause damage or threaten to damage structures or utilities, cease excavation and modify equipment and methods to reduce ground movements.
- F. Where excavation exposes existing utilities, replace any bedding in a manner to restore the original grade and level of support of the pipe or conduit. Complete the backfill above the existing pipeline or conduit with the backfill shown or specified, or as directed by the Owner.

3.4 PIPE LAYING TOLERANCES

- A. Pipe shall be installed in trench excavation to within 0.5 foot of established horizontal alignment, and to within 0.15 foot of established grade.
- B. Variation shall be further limited as necessary to prevent a level or reverse sloping invert.
- C. In no case shall joint deflections exceed 75% of the maximum allowable deflection recommended by the pipe manufacturer.

3.5 CONTROL OF WATER

- A. Conform to Section 31 23 19 Control of Water, and the following additional requirements.

- B. Maintain the water table below the bottom of the excavation sufficiently to ensure a firm working surface.
- C. Control groundwater to prevent raveling of excavation sides.
- D. Provide dams, cutoffs, or other barriers periodically to preclude transport of water along the trench bottom during construction.

3.6 FOUNDATION STABILIZATION

- A. Where the existing material in the bottom of the excavation is incapable of supporting the pipe, manhole, or structure, over-excavate and remove and replace the material as specified in Section 31 20 00 Earthwork.
- B. The use of foundation stabilization material made necessary by the Contractor's failure to maintain bottom stability due to inappropriate means of ground support or groundwater control shall be at no additional cost to the Owner.

3.7 PLACING GEOTEXTILE

- A. Place geotextile as specified in Section 31 20 00 Earthwork.
- B. Extend geotextile across the full width of the trench and up the sides to the top of the pipe zone, or across the width of base material for manholes and miscellaneous concrete structures.

3.8 TRENCH EXCAVATION AND BACKFILL

- A. Trench Excavation
 - 1. Trench width shall be as shown on the Drawings, and shall be no greater than necessary to ensure working room to properly and safely place and compact backfill in the pipe zone.
 - 2. Excavate the trench to maintain vertical side walls at least to the top of the pipe.
 - 3. Side sloping or "benching down" of the trench will not be permitted where the trench is excavated within a permanent pavement, or where such side sloping or benching would endanger existing underground utilities or structures. Confine trench widths to dedicated rights-of-way or construction easements.
 - 4. The length of open trench in any location during work periods shall not exceed 50 feet. At the end of the workday, not more than one pipe-length of open trench shall be permitted.
 - 5. Open trench within the right-of-way or within 75 feet of any public roadway shall be barricaded with concrete Jersey barriers or covered with road plates.

6. Where pipe is to terminate into manholes or miscellaneous structures, place and compact backfill for the manhole or structure to a minimum elevation of 1 foot above top of pipe prior to excavating trench and placing pipe.
7. A portable trench shield used during backfill operations shall be lifted above each layer of backfill material prior to compacting the layer. Do not advance the trench shield in a manner that would separate the pipe joint or leave voids in the ground.

B. Placing Pipe Bedding Material

1. Immediately prior to placing pipe bedding, remove any loose, sloughing, or caving soil from the bottom and sidewalls of the excavation. Provide a uniform, stable trench bottom.
2. Place pipe bedding material across the full width of the trench. Grade and compact to provide firm, uniform, and continuous support along the pipe barrel.
3. Spread pipe bedding material in uniform, loose lifts. Vibrate or tamp each lift to maximize stability of the material, applying at least two passes of compactive effort. Vibrate using a vibratory plate compactor, or tamp using the backhoe bucket.

C. Laying and Jointing Pipe

1. Examine pipes and fittings for defects on arrival on site and just before laying. Defective pipe or fittings shall be removed from the site and replaced with a sound pipe or fitting.
2. Pipe shall be lowered, not dropped, into the trench. Cable, rope, or other devices for lowering pipe and fittings into trench shall be attached to the outside of the pipe or fitting, not through the interior.
3. Lay pipe with bell ends open to the direction of pipe laying, generally upgrade. Prevent soil or foreign material from getting into the pipe during the laying operation.
4. Ensure that each section of pipe is continuously supported by compacted bedding material over full length of the barrel. Excavate bell holes in pipe bedding, no larger than necessary, so that no part of the load is supported by the bells or couplings.
5. Check each pipe for proper line and invert grade, and make appropriate adjustments, prior to making the joint. If grade is low, remove pipe, prepare bedding for full pipe length, and re-lay. Do not bring pipe invert to grade by packing bedding material at points along its length.
6. Clean all surfaces to be joined, particularly the gasket, to remove any soil or foreign material prior to applying joint lubricant. Assemble the joint in accordance with the pipe manufacturer's recommendations. Use mechanical

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means to pull pipe together and close joints tightly "home" as defined by the pipe manufacturer. Do not use excessive force that may result in over-assembled joints, dislodged gaskets, or damaged ends of pipe.

7. If the joint cannot be properly made using normal force, disassemble the joint and check the position of the gasket. If the joint cannot be properly made after verifying position of the gasket, remove the pipe and replace with satisfactory pipe.
8. Lifting holes in the pipe shall be sealed with specifically manufactured plugs, grouted into place.
9. Pipe shall not be deflected either vertically or horizontally in excess of the printed recommendations of the pipe manufacturer.
10. When field cutting or machining the pipe is necessary, use only tools and methods recommended by the pipe manufacturer and approved by the Owner.
11. At the close of pipe laying operations each day or whenever laying operations are not in progress, cover and secure the end of the pipe to prevent entry of persons, small animals, and foreign material.

D. Placing Backfill Around and Above the Pipe

1. Backfill trench as soon as practicable after pipe is installed to prevent disturbance of pipe and bedding.
2. After laying and jointing the pipe, place embedment material. Completely fill the space under the haunch of the pipe by shovel slicing, and compact the material under the haunch of the pipe with spud bars.
3. Place cover material and compact to a height above the barrel as shown on the Drawings. Raise the material uniformly on each side of the pipe so as not to laterally displace the pipe.
4. Install identification tape as indicated.
5. Do not permit backfill to free fall onto pipe with less than 2 feet of cover over the top of the pipe. Do not allow backfill to drop with force capable of damaging or displacing the pipe.
6. After completion of at least 2 feet of compacted backfill over the top of pipeline, compaction equipment weighing no more than 8,000 pounds may be used to complete the trench backfill.
7. Stop backfill at the necessary grade to provide for placement of subgrade, surface course, or topsoil as required.

3.9 BORING UNDER OBSTRUCTIONS

- A. The Contractor may, with the approval of the Owner, tunnel or bore under roadways, driveways, sidewalks, curbs or other obstructions provided that any tunnel section exceeding 2 feet in length is supported in conformance with OSHA regulations.
- B. The tunneling method used shall be compatible with requirements for maintaining line and grade, shall fully support overlying utilities or structures, and shall not damage the carrier pipe. Pipe ramming as a method of tunneling or boring is prohibited.
- C. The annular space between the carrier pipe and the initial tunnel support system, or between the carrier pipe and the ground, shall be backfilled completely with grout having a minimum 28-day compressive strength of 2,000 psi. Grouting shall be completed no later than one day of installing the carrier pipe.

3.10 STRUCTURE EXCAVATION AND BACKFILL

- A. Except where indicated otherwise, excavation shall be carried to an elevation 6 inches below the bottom of the footing or slab and brought back to grade with compacted materials acceptable for placement beneath structures. Where mud mats are indicated or added by the Contractor, excavation shall be carried to an elevation 6 inches below the bottom of the mud mat.
- B. Backfill around concrete structures only after the concrete has attained 2/3 of the specified compressive strength. Obtain the Owner's approval of concrete work and attained strength prior to backfilling.
- C. Backfill shall not be placed around water-retaining structures until the structures have been tested, and the structures shall be full of water while backfill is being placed.
- D. Remove all form materials and trash from the excavation before placing any backfill. Remove loose, sloughing, or caving soil from bottoms and sidewalls of excavation.
- E. Raise backfill uniformly around structures to prevent unbalanced lateral loading. Place backfill in such a manner that any water in the excavation will be displaced by backfill and not trapped therein.
- F. Do not operate earth-moving equipment within 5 feet of walls of structures for the purpose of depositing or compacting backfill materials. Where compacting backfill adjacent to walls, use hand-operated tampers or other equipment that will not damage the structure.

3.11 ROCK EXCAVATION

- A. Before beginning rock excavation, expose the rock by removing the common material above it. The Owner, with the Contractor, will measure and record the volume of rock to be removed. The method of determining the volume of rock to

TRENCH EXCAVATION

be excavated shall be agreed upon for each occurrence where rock is encountered. All such agreements shall be made a matter of record each day that rock is encountered. Then break with power-operated rock breakers, and excavate the material.

3.12 USE OF SHEETING AND BRACING

- A. To protect the existing sensitive structures from damage as a result of ground settlement adjacent the trench excavation, support the trench excavation with interlocking sheeting, in the area shown on the Drawings. Drive the sheeting in advance of the excavation, and brace with preloaded struts so as to minimize ground movements.
- B. Sheeting placed below the top of the pipe zone, or below the base of manholes and miscellaneous concrete structures, shall be left in place unless otherwise approved by the Owner. Wood bracing members shall be removed. Permission by the Owner to remove sheeting shall not relieve the Contractor of responsibility for protection of persons or property.
- C. Where sheeting is removed, it shall be done as the excavation is backfilled, and in a manner to maintain stability and strength of soils, and to avoid disturbance to adjacent structures. Voids left on removal of sheeting shall be filled to prevent future subsidence.
- D. Sheeting may be left in place at the Contractor's expense and with the written approval of the Owner, provided that the top 5 feet below the final grade is removed. Provide additional clearance as necessary for new or relocated utility lines or other structures.
- E. The Contractor shall be responsible for adverse effects of vibrations associated with driving sheeting.

3.13 DISPOSAL OF EXCESS EXCAVATED MATERIAL

- A. Dispose of excess excavated material as specified in Section 31 20 00 Earthwork.

- END OF SECTION -

SECTION 31 23 19 - CONTROL OF WATER

PART 1 -- GENERAL

1.1 SUMMARY

- A. The work of this Section includes control, handling, treatment, and disposal of groundwater, surface water, construction water, and any other water that may be encountered during the course of the Work.
- B. Additional requirements for control of water specific to particular types of excavations are specified in other Sections.

1.2 REGULATORY REQUIREMENTS

- A. Water from excavations shall be discharged into the nearest sanitary sewer in compliance with applicable codes and regulations. Discharge into storm sewers, open waterways, or on open ground is prohibited.
- B. Storm water discharge to storm sewers, watercourses, lakes, and wetlands shall conform to the Stormwater Pollution Prevention Plan.

1.3 ACTION SUBMITTALS

- A. Submit a Water Control Plan describing, for each aspect of the work where dewatering will be involved, the proposed method for control, handling, treatment, and disposal of water. As a minimum, describe the following:
 - 1. Water control methods (such as cutoff, sumping, predrainage), equipment, standby equipment, and power supply.
 - 2. Schedule of installation and operation of water control facilities.
- B. Submittal requirements for Water Control Plans may be met by including the required information with methods submittals required under other sections including:
 - 1. Section 31 23 16 Trench and Minor Structure Excavation
 - 2. Section 31 71 30 Trenchless Excavation
- C. Submit a Water Treatment and Disposal Plan describing the proposed method for treatment and disposal of water. As a minimum, describe the following:
 - 1. Sediment and pollution control facilities.
 - 2. Discharge locations to be used.
- D. The Owner may require resubmittal if the system or any part thereof is materially modified during installation or operation.

CONTROL OF WATER

PART 2 -- PRODUCTS

Not used.

PART 3 -- EXECUTION

3.1 GENERAL REQUIREMENTS FOR CONTROL OF WATER

- A. Control, handle, treat, and dispose of water of any origin (including groundwater, surface water, and pipeline flows) to allow construction to proceed on stable subgrades, to maintain stability of excavations, to prevent flooding, and to prevent damage to the environment, structures, and adjacent property. The Contractor shall be responsible for control of water at all times during construction, and shall provide adequate backup systems to accomplish control of water.
- B. Methods of control, handling, and disposal of water shall be by whatever means are necessary and in conformance with this Section to maintain satisfactory working conditions and to maintain the progress of the work. If, after installation and while in operation, the water control system fails to meet the performance requirements of this Section, the Contractor shall modify or augment the water control system, at no additional cost to the Owner.
- C. The Contractor shall bear the cost of loss or damage arising from removal or disturbance of groundwater, including subsidence or loss of structural support, that may occur in the prosecution of the work.
- D. Perform this work without interference with the operations of other contractors, or the rights of public and private owners.
- E. Contractor shall be responsible for evaluating the need to install dewatering wells, including gravity wells and wellpoint systems.
- F. Contractor shall be responsible for the effects of groundwater chemistry and bacteriology on dewatering wells.

3.2 CONTROL OF SURFACE WATER

- A. Prevent surface water, including runoff from adjacent properties, backup from storm sewers, and leakage from adjacent utilities, from draining into excavations. Intercept and divert surface water by use of surface grading, dikes, curbs, ditches, sumps, and other means.
- B. Extend the initial ground support system above outside grade as necessary to prevent flooding of the excavation from surface runoff. Allow no ponding of water outside the excavation.
- C. Assess and take appropriate precautions to prevent storm sewer overflow from flooding excavations.

CONTROL OF WATER

3.3 CONTROL OF WATER IN EXCAVATIONS

- A. Control water inflows to excavations to prevent loss of fines, soil erosion or piping, flowing ground, softening of subgrade or foundation soils, or interference with the progress of the work.
- B. Allow no standing water in the bottom of the excavation during construction activities such as placement of bedding and backfill, placement of pipe, erection of formwork, placement and curing of concrete or other permanent construction. Water shall not be allowed to rise upon or flow over backfill material.
- C. Reduce or counteract groundwater pressure in soils outside the excavation to prevent bottom instability in trenches and shafts, and to ensure a firm working surface.
- D. Provide standby pumps and standby power supply where disruption of water control systems could allow water inflows to threaten the Work or the safety of personnel. Take immediate steps to control water inflow to the excavation that could cause loss or damage to adjacent structures or property.
- E. Temporary drains used for construction shall be removed or grouted completely when no longer required.
- F. Loss of fines through a leaky initial support system shall be prevented by the use of straw, hay, oakum, gravel, geotextile, or other filtering material.
- G. Convey all water from excavations through pipes or hoses. Conveyance in open ditches or trenches is prohibited. No water shall be discharged into the Work completed or under construction.

3.4 TREATMENT AND DISPOSAL OF WATER

- A. Treat discharge water from excavations using settling basins, dewatering filter bags, on-site treatment plant, or other means to remove suspended solids, oils, cement, bentonite, and other visible contaminants such that discharge appears clear. Reduce contaminant concentrations to levels acceptable to authorities having jurisdiction over receiving sewers.
- B. Select treatment systems that can be readily expanded if greater capacity becomes necessary during the course of the work.
- C. On completing the work, clean out sediments and residues from settling basins and treatment facilities, and dispose of them off the Site in accordance with applicable requirements.

- END OF SECTION -

SECTION 32 17 13 – WALKS, ROAD AND PARKING APPURTENANCES

PART 1 - GENERAL

1.01 SCOPE OF WORK

- A. Furnish and install pavement and perform related WORK necessary to complete WORK shown or specified. The CONTRACTOR shall be responsible for all WORK involved in the repair and replacement of existing streets, roads, drives, parking areas, curbs, gutters, sidewalks, aprons, curb ramps, and other paved areas damaged or destroyed during construction of the WORK. Replacement in kind with respect to base courses, surface courses, and thicknesses, unless otherwise indicated or directed. Finish elevations, lines, and grades shall be the same as items removed unless otherwise shown on the drawings.
- B. Subgrade preparation shall be as specified for Excavation and Backfill, established elsewhere in the Contract Documents, and as specified herein.
- C. Codes, specifications, and standards referred to by number or title shall form a part of this specification to the extent required by the reference thereto. Latest revisions shall apply, unless otherwise indicated.
- D. Perform cutting and patching of pavements as indicated, specified, or directed by OWNER.
- E. The CONTRACTOR shall obtain all permits and pay all applicable fees. The cost of said fees shall be included in the applicable bid items to which it pertains.
- F. Except as specifically modified in this specification, paving and surfacing operations and materials shall comply with applicable sections of the current Ohio Department of Transportation (ODOT) Construction and Material Specifications, including current revisions thereto.
 - 1. Item 202 - Removal of Structures and Obstructions
 - 2. Item 203 - Roadway Excavation and Embankment
 - 3. Item 204 - Subgrade Compaction & Proof Rolling
 - 4. Item 304 - Aggregate Base
 - 5. Item 401 - Asphalt Concrete Pavements – General
 - 6. Item 407 - Tack Coat
 - 7. Item 448 - Asphalt Concrete
 - 8. Item 451 - Reinforced Portland Cement Concrete Pavement
 - 9. Item 452 - Non-Reinforced Portland Cement Concrete Pavement
 - 10. Item 499 - Concrete - General
 - 11. Item 508 - Falsework and Forms

WALKS, ROAD AND PARKING APPURTENANCES

- 12. Item 509 - Reinforcing Steel
- 13. Item 608 - Walks, Curb Ramps, and Steps
- 14. Item 640 - Pavement Markings

1.02 RELATED DOCUMENTS

- A. Section 01 33 00 - Contractor Submittals
- B. Section 03 31 00 - Cast-in-Place Concrete
- C. Section 31 20 00 - Earthwork
- D. Section 32 17 23 – Pavement Markings

1.03 REFERENCES

- A. Ohio Department of Transportation (ODOT) Construction and Material Specifications (current edition)
- B. American Society for Testing and Materials (ASTM)
- C. American Concrete Institute (ACI)

1.04 DEFINITIONS – NOT USED

1.05 QUALITY ASSURANCE AND QUALITY CONTROL

- A. Testing Laboratory Services:
 - 1. The OWNER shall employ an independent testing laboratory to perform necessary field density tests to demonstrate to the satisfaction of the OWNER that proper compaction is obtained and that placement conditions are in compliance with the specifications.
 - 2. The CONTRACTOR shall employ a testing laboratory service for all testing required to determine mix designs, maximum theoretical densities, and specification compliance.
- B. Installer shall have at least two (2) years' experience in installing concrete curb-gutter, sidewalks and curb ramps similar to those for this Project.

1.06 SUBMITTALS

- A. Submit the following:
 - 1. Name and location of bituminous mixing plant and concrete ready-mix plant.
 - 2. Type and composition of proposed materials and mixes, including moisture-density curves.
 - 3. Certificates of Compliance certifying compliance with the referenced specifications and standards.

WALKS, ROAD AND PARKING APPURTENANCES

4. Statement of qualification for independent testing laboratory.

5. Test Results: Asphalt

- a. Mix Design
 - 1.) Aggregate gradation
 - 2.) Asphalt content
 - 3.) Stability number
- b. Uncompacted Mix
- c. Field Density
 - 1.) Asphalt content
 - 2.) Aggregate gradation
- d. Permeability
- e. Asphalt Temperature

6. Test Results: Concrete

- a. Mix Design
 - 1.) Aggregate gradation
 - 2.) Cement content
 - 3.) Water content
 - 4.) Air Content
- b. Slump
- c. Pavement thickness
- d. Compressive Strength

1.07 JOB CONDITIONS

- A. Do not place paving and surfacing materials on wet surface or when weather conditions would prevent the proper construction of paving and surfacing.
- B. Do not place aggregates on frozen subgrade or when air temperature is below 35 degrees °F.
- C. Weather limitations for the placement of asphalt concrete, and tack coat, shall be as stated in ODOT Items 401.06 and 407.04, respectively.
- D. Placement of concrete pavement shall be as stated in ODOT Item 451.06.
- E. Do not place paving and surfacing materials when natural light is not sufficient to properly observe WORK on operations.
- F. All pavement markings shall be the entire width of the pavement per ODOT Item 640.

PART 2 - PRODUCTS

2.01 AGGREGATE BASE

- A. Aggregate base shall be in conformance with ODOT Item 304.

2.02 CONCRETE BASE

- A. Concrete base shall be ASTM C595 Blended Hydraulic Cement, Type IL

2.03 ASPHALT CONCRETE

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- A. Asphalt concrete pavement shall conform to Asphalt Concrete Pavements – General as referenced in ODOT Item 401.
- B. Surface and intermediate courses shall conform to ODOT Item 448, Types 1 and 2.
- C. Tack coat shall conform to ODOT Items 407.

2.04 REINFORCED CONCRETE

- A. Reinforced cement concrete pavement shall be Reinforced ASTM C595 Blended Hydraulic Cement, Type IL.

2.05 NON-REINFORCED CONCRETE

- A. Non-reinforced cement concrete pavement shall conform be Non-Reinforced ASTM C595 Blended Hydraulic Cement, Type IL.

2.06 WALKS AND CURB RAMPS

- A. Concrete Sidewalks, and Curb Ramps shall conform to Walks, Curb Ramps & Steps as referenced in ODOT Item 608.

2.07 CURBING

- A. Concrete Curbing shall conform to Curbing, Concrete Medians, and Traffic Islands as referenced in ODOT Item 609.

2.08 REINFORCED CEMENT CONCRETE PAVEMENT, WALKS, AND STEPS

- A. Forms:
 - 1. Steel, wood, or other suitable material of size and strength to resist movement during concrete placement and to retain horizontal and vertical alignment until removal of forms. Use straight forms, free of distortion and defects.
 - 2. Forms shall meet the requirements of ODOT Item 508.
 - 3. Coat forms with a non-staining form release agent that will not discolor or deface surface of the concrete.
- B. Welded Wire Mesh:
 - 1. Welded plain cold-drawn steel wire fabric, ASTM A185 and ODOT Item 709.10.
- C. Reinforcing Bars:
 - 1. Deformed Steel Bars: ASTM A615 Grade 60 and ODOT Item 709.01.
- D. Concrete Materials:
 - 1. Comply with requirements of applicable referenced ODOT specifications for concrete materials, admixtures, bonding materials, curing materials, and other materials as required.
- E. Expansion Joint Materials:

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1. Comply with requirements of ODOT Items 705.03 and 705.04 for preformed expansion joint fillers and sealers.
- F. Curing and Sealing Compound:
1. Comply with requirements of ODOT 705.07 (Type 2).
- G. Concrete Mix, Design, and Testing:
1. Comply with requirements herein and of ODOT Items for concrete mix design, sampling, testing, and quality control.
 2. Design mix to produce normal weight concrete consisting of ASTM C595 Blended Hydraulic Cement, Type IL, aggregate, water-reducing or high range water reducing admixture (super-plasticizer), air-entraining admixture, and water, as specified in ODOT specifications.
 3. Compressive Strength: Class QC, 4,000 psi, minimum at 28 days, unless Class MS or FS is required. Class MS or FS shall reach a minimum strength of 400 PSI at 24 hours.
 4. Slump Range: In accordance with ODOT Item 455.
 5. Air Content: Between 4 percent to 7-1/2 percent, ASTM C-173.04 or C-231.04.
- 2.09 PERFORATED UNDERDRAIN PIPE
- A. Provide corrugated polyethylene tubing in compliance with ODOT Item 605 6-inch underdrain with circular knit geotextile fabric per ODOT 712.09.
- 2.10 PERMANENT PAVEMENT MARKINGS
- A. See Section 32 17 23 – Pavement Markings.

PART 3 - EXECUTION

3.01 GENERAL

- A. The CONTRACTOR is responsible to provide equipment, workmanship, and materials required to achieve a finished product which meets these specifications.
- B. Use compaction equipment suitable for the material being placed. Compacting equipment shall include at least one (1) piece of equipment capable of providing a smooth, even surface for the pavement surface course.
- C. Prior to placing paving and surfacing materials, level the subgrade to produce smooth, even finished pavement grades. Fill all gullies and ruts with additional ODOT 304 aggregate base material. Subgrade and aggregate base materials shall be compacted in accordance with ODOT Item 203.
- D. Do not place paving and surfacing material before subgrade is reviewed and accepted by the OWNER. Do not place paving and surfacing materials on a frozen or muddy subgrade.

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- E. Provide adequate drainage at all times to prevent water from standing on subgrade.

3.02 CUTTING AND PATCHING

- A. At time of installing permanent pavement, edges of existing pavement shall be cut back 24-inches or more, as required, to sound undamaged material with vertical face cleaned and prepared for bonding with new pavement as indicated, specified, or as directed by OWNER.
- B. Where WORK is located in sidewalks and similar narrow paved areas, the whole width shall have permanent pavement replaced.
- C. Disturbed or eroded gravel base course to be restored as required before placing pavement.
- D. Manhole covers, catch basin grates, valve boxes, monument boxes and similar items shall be adjusted to conform to pavement grade or as directed by the OWNER; items shall be removed and reconstructed as necessary. This WORK shall be completed prior to final paving.
- E. Surface of existing pavement to which new pavement is to bond shall be treated with cut back asphalt or emulsified asphalt, applied at a rate between 0.05 and 0.09 gallons per square yard of surface.

3.03 ASPHALT CONCRETE

- A. All base and asphalt concrete materials shall be installed as per the ODOT "Construction and Materials Specifications," current edition.
- B. Base and surface asphalt courses shall be constructed in accordance with ODOT Item 401.
- C. When the previously constructed course is granular, or concrete a tack coat shall be applied, in accordance with ODOT Item 407.
- D. Where the surface course is not placed after completion of the intermediate course, the CONTRACTOR shall provide a tack coat in accordance with ODOT Item 407.
- E. Spreading, finishing, and compaction of asphalt courses shall conform to ODOT Item 401. In-place density of the compacted mixture shall be greater than or equal to 98 percent of maximum theoretical density as defined by ASTM D-698 (Standard Proctor) and a moisture content with 2 percent optimum.

3.04 REINFORCED CEMENT CONCRETE PAVEMENT, WALKS, AND STEPS

- A. ASTM C595 Blended Hydraulic Cement, Type IL pavement shall consist of a coarse aggregate base and a reinforced Portland cement concrete surface, as shown on the drawings or specified.
- B. All base and ASTM C595 Blended Hydraulic Cement, Type IL concrete shall be installed per ODOT Items 304, 451, 499, 508, 509, and 608.

3.05 CONCRETE PAVEMENT

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- A. The CONTRACTOR shall develop and submit to the OWNER a proposed concrete mix design to meet the requirements of this section. No concrete shall be placed prior to approval of the mix design by the OWNER.
- B. Expansion and contraction joints shall be installed as indicated on the drawings, as required, and as directed by the OWNER. Expansion joints shall be required whenever new concrete abuts fixed objects or existing concrete surfaces, whether or not shown on the drawings.
- C. The CONTRACTOR shall always have materials available to protect the surface of the concrete against precipitation. These materials shall consist of burlap, curing paper, or plastic sheeting.
- D. If existing roadway, sidewalk, curb, apron, curb ramp, etc. is to be removed and replaced with new roadway, sidewalk, curb, apron, curb ramp, etc., extended removal of existing roadway, sidewalk, curb, apron, curb ramp, etc., to the nearest joint of suitable quality or as directed by the OWNER.

3.06 FIELD QUALITY CONTROL

- A. Roadway aggregate materials shall be tested in accordance with these specifications. Asphalt paving shall be tested in accordance with ODOT specifications and testing laboratory recommendations. All quality control field testing services shall be provided by the OWNER.

3.07 CLEANING

- A. Clean job site of rubbish, excess material, structures, and equipment. Restore damaged property.

3.08 PERFORATED UNDERDRAIN PIPE

- A. Provide underdrain piping to match existing.
- B. Provide geotextile fabric.
- C. Provide ODOT #57 for bedding.
- D. No separate payment shall be made for underdrain repair or replacement. Payment shall be included in the bid item to which it pertains.

END OF SECTION

SECTION 32 31 13 – CHAIN LINK FENCES AND GATES

PART 1 -- GENERAL

1.01 SUMMARY

A. Section Includes:

1. This section specifies the requirements for materials and installation for chain link fencing and gates and appurtenant work.

B. Related Requirements

1.02 MEASUREMENT AND PAYMENT

A. Chain Link Fencing

Chain-link fencing to include supply and installation of chain-link fabric and hardware, barbed wire and barbed wire hardware, fence posts, excavation of post holes, cast-in-place concrete footings, adjust fence tension, alter ground levels at fence to close gaps, restore surface at post holes, and all incidental work.

Payment: Unit price bid per lineal feet (metre) of fence installed, excluding gate openings.

Measurement: Measured length in the horizontal plane.

B. Chain Link Gates

Chain-link gates to include supply and installation of chain-link gate frames, gate fabric and gate hardware, gate posts, excavation of gate post holes, cast-in-place concrete footings, and all incidental work.

Payment: Unit price bid per complete gate unit installed.

Measurement: Per each.

1.03 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

A. Reference Specifications

01 33 00	Submittal Procedures
03 30 00	Cast-in-Place Concrete

B. Reference Standards

ASTM International (ASTM)	
ASTM A53	Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
ASTM A116	Standard Specification for Metallic-Coated, Steel Woven Wire Fence Fabric
ASTM A153/A153M	Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware
ASTM A702	Standard Specification for Steel Fence Posts and Assemblies, Hot Wrought
ASTM A780/A780M	Standard Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings
ASTM A90/A90M	Standard Test Method for Weight [Mass] of Coating on Iron and Steel Articles with Zinc or Zinc-Alloy Coatings
ASTM B117	Standard Practice for Operating Salt Spray (Fog) Apparatus
ASTM C94/C94M	Standard Specification for Ready-Mixed Concrete
ASTM F1043	Standard Specification for Strength and Protective Coatings on Metal Industrial Chain-Link Fence Framework
ASTM F1083	Standard Specification for Pipe, Steel, Hot-Dipped Zinc Coated (Galvanized) Welded, for Fence Structures
ASTM F567	Standard Practice for Installation of Chain Link Fence
ASTM F626	Standard Specification for Fence Fittings
ASTM G152	Standard Practice for Operating Open Flame Carbon Arc Light Apparatus for Exposure of Nonmetallic Materials
ASTM G153	Standard Practice for Operating Enclosed Carbon Arc Light Apparatus for Exposure of Nonmetallic Materials
ASTM G154	Standard Practice for Operating Fluorescent Light Apparatus for UV Exposure of Nonmetallic Materials
ASTM G155	Standard Practice for Operating Xenon Arc Light Apparatus for Exposure of Non-Metallic Materials
ASTM F1184	Standard Specification for Industrial and Commercial Horizontal Slide Gates

1.04 SUBMITTALS

A. General

1. Furnish submittals in accordance with Section 01 33 00– Submittal Procedures.

B. Shop Drawings

1. Manufacturer's technical data, product specifications, standard details, certified product test results, installation instructions and general recommendations.
2. Scale layout of fencing, gates, and accessories. Drawings shall show fence height, post layout, including sizes and sections; post setting and bracing configuration, details of gates and corner construction, barbed wire support arms, and other accessories.

C. Samples

1. Samples of proposed fence components, at least 12-inches long, to illustrate the selected color and finish.

1.05 QUALITY ASSURANCE

A. Qualifications

1. Manufacturers

- a. Chain link fencing and gates shall be products of a single manufacturer which has been successfully engaged in the production of such items for a period of at least 5 years

2. Installers

- a. Installation of the chain link fence shall be by the manufacturer or by a firm accepted and licensed by the manufacturer.

PART 2 -- PRODUCTS

2.01 GENERAL

- A. Provide fencing materials conforming to the requirements of ASTM A116, ASTM A702, ASTM F626, and as specified.
- B. Dimensions indicated herein for roll-formed pipe and wire gauges are outside dimensions, excluding coatings.
- C. All fencing materials shall be hot-dip galvanized after fabrication.

2.02 STEEL FABRIC

- A. The height of the fabric shall be 8 feet.
- B. Provide fabric consisting of No. 9 gauge wires woven into a 1 inch diamond mesh, with dimensions of fabric and wire conforming to ASTM A116, ASTM A702 and ASTM F626.
- C. Fabric shall be galvanized in accordance with ASTM A392, Class II, with minimum 2.0 ounces zinc per square foot of coated surface.
- D. Poly Vinyl Chloride (PVC) color coated steel chain link fabric per ASTM F668 Class Class 2B Fused and adhered to metallic coated steel wire, except that the wire core shall measure 9 gauge prior to application of coating. Color of chain link fabric shall be selected by Owner, as per ASTM F934.
- E. Fabric shall be furnished with knuckled top and twisted bottom selvages.

2.03 FENCE FRAMEWORK

A. Posts and Rails

1. Posts and Rails hot-dip galvanized cold rolled welded ASTM A53, Grade A, Schedule 40 steel pipe, with minimum 1.8 ounces zinc per square foot of coated surface.
2. After galvanizing, framework, fittings, and accessories shall be finished with manufacturer's standard thermally bonded PVC finish, not less than 10-mils thick.
3. Post and Rail Dimension Schedule

Component	Fabric Height		
	< 6 feet	≥ 6 feet and ≤ 8 feet	> 8 feet
Line Post	1.900 inch OD 0.145 inch wall	2.375" OD 0.154" wall	2.875" OD 0.203" wall
Terminal Post End and Corners	2.875 inch OD 0.203 inch wall	3.500" OD 0.216" wall	4.500" OD 0.237" wall
Rail and Brace	1.660 inch 0.140 inch wall		

Component	Gate Panel Width (opening size for single swing gates or half of opening size for double swing gates)		
	< 10 feet	≥ 10 feet and < 15 feet	≥ 15 feet and ≤ 25 feet
Terminal Post Gates	3.500 inch OD 0.216 inch wall	4.500 inch OD 0.237 inch wall	6.625 inch OD 0.280 inch wall

2.04 FENCE HARDWARE, FITTINGS, AND ACCESSORIES

- A. Fence Hardware, Fittings, and Accessories shall conform to ASTM F626. Sleeves, bands, clips, tension bars, fastener and fittings, shall be galvanized with minimum 1.2 ounce per square foot of coated surface.
- B. Tension Wire
 1. Tension wire shall be located at the bottom of the fabric and shall consist of No. 9 gauge coated coil spring wire of metal and finish to match fabric.
- C. Fabric Tie Wires
 1. Fabric tie wires shall be No. 9 gauge galvanized steel wire of the same finish as the fabric. Aluminum ties shall not be used.
- D. Post Brace Assembly
 1. Post brace assembly shall be provided at each end post, gate post and at both sides of each corner post and intermediate brace post. Material used for brace shall be same as top rail. Truss bracing between line posts shall be achieved with 0.375 inch (9.53 mm) diameter rod and adjustable drop forged turnbuckle type tensioner.

E. Post Tops and Rail Ends

1. Post tops and rail ends shall be cast aluminum, cast iron, or pressed steel weather-tight closure caps, designed for containment of top rail and positive permanent attachment to post.

F. Tension (Stretcher) Bars

1. Stretcher bars shall be one-piece lengths equal to the full height of the fabric, with minimum cross-section of 3/16-inch by 3/4 inch (4.75 mm by 19.05 mm). One stretcher bar shall be provided for each gate and end post, and 2 for each corner and intermediate brace post.

G. Tension (Stretcher) Bar Bands

1. Stretcher bar bands shall be one-piece fabrications designed to secure stretcher bars to end, corner, intermediate brace, and gate posts. Bands shall have a minimum cross-section of 1/8-inch by 3/4-inch (3.18 mm by 19.05 mm).

H. Barbed Wire Supporting Arms

1. Supporting arms shall be manufacturer's standard fabrication, of metal and finish to match fence framework, with provision for anchorage to each post and attachment of three rows of barbed wire to each arm. Supporting arms may be either attached to posts or integral with post top weather cap.
2. Supporting arm shall hold three strands of barbed wire, top strand to be 12 inches above fabric; vertical or at 45° overhang, as specified. 45° arm type shall be capable of withstanding 250 pounds of downward pull at outermost end.

I. Barbed Wire

1. Barbed wire shall conform to ASTM A121, with three strands, two 12.5 gauge wires per strand. Each wire shall be zinc-coated with minimum 0.8 ounces zinc per square foot of coated surface. Barbs to have 4 points spaced at a maximum of 6 inches.

J. Nuts, bolts and screws shall be steel, minimum size 3/8-inch diameter, hot-dip galvanized after fabrication.

K. PVC slats shall be a PVC material similar to the PVC fabric coating or high-density virgin polyethylene slats with an ultraviolet inhibitor. The slats shall be a tubular shape with a nominal wall thickness of 0.03 inch and be installed with a retaining channel top and bottom. The color shall be as indicated or as selected by the Engineer.

2.05 GATES

A. Fabrication

1. Perimeter frames of gates swing shall be fabricated from same metal and finish as fence framework. Gate frames shall be assembled by welding. Welds shall be ground smooth. Gate frames and any ungalvanized hardware, shall be hot-dip galvanized after fabrication. Horizontal and vertical members shall be provided to ensure proper gate operation and attachment of fabric, hardware and shall be hot-dip galvanized after fabrication.

2. Where barbed wire is indicated above gates, vertical members shall be extended and fabricated as required to receive barbed wire supporting arms.

B. Swing Gates]

1. Perimeter frames of swing gates shall be constructed of the same pipe or "H" column members as the top rails and shall be fabricated by welding. Welds shall be ground smooth prior to hot-dip galvanizing.
2. Hardware and accessories shall be provided for each gate, galvanized in conformance with ASTM A153, and in accordance with the following:
 - a. Hinges shall be of size and material to suit gate size, non-lift-off type, offset to permit 180-degree gate opening. Three hinges shall be provided for each leaf 6 feet or more in height. Two hinges shall be provided for each leaf less than 6 feet in height.
 - b. Latch shall be forked type or plunger-bar type, permitting operation from either side of the gate, with padlock eye as an integral part of the latch.
 - c. Keeper shall be provided which automatically engages the gate leaf and holds it in the open position until it is manually released.
 - d. Gate stops shall be provided for double gates, consisting of mushroom type flush plate with anchors, set in concrete, and designed to engage center drop rod or plunger bar. Locking device and padlock eyes shall be provided as an integral part of the latch, permitting both gate leaves to be locked with a single padlock.

C. Horizontal Slide Gates

1. Horizontal slide gates shall be fabricated in accordance with fabricated in accordance with ASTM F1184.
2. Gates designed to open or close by applying an initial pull force no greater 40 pounds.
3. PVC coated horizontal slide gates and posts shall match the coating type and color as that specified for the fence framework.
4. Cantilever Slide Gates (ASTM F1184 Type II)
 - a. Cantilever slide gates shall have and external roller design (Class 1).
 - b. Horizontal top and bottom steel pipe "track" members to be 2.375 inch outer diameter. Vertical and internal members, 1.900 inch outer diameter. Pipe shall be hot-dip galvanized cold rolled welded ASTM A53, Grade A, Schedule 40 steel pipe, with minimum 1.8 ounces zinc per square foot of coated surface.
 - c. Gate frame to be fabricated by welding, vertical and horizontal members installed no greater than 8 ft. apart. Welded joints are to be protected by applying zinc-rich paint in accordance with ASTM Practice A780.
 - d. Provide positive locking latch, pressed steel, galvanized after fabrication. Galvanized steel drop bars to be provided with double gates.

- e. Chain link fabric to match the fence system.

2.06 CONCRETE

- A. Concrete shall be provided in accordance with Section 03 31 00 - Cast-In-Place Concrete, ASTM C94/C94M , and the following mix design:

Parameter	Value
Min. 28 Day Compressive Strength	2900 psi
Slump	2-3/8 ±3/4 inch
Entrained Air Limits (% by volume)	6%
Max. Aggregate Size	0.75 inch
Max. Water to Cementing Materials Ratio (by mass)	0.45
Min. Portland Cement Content	18 lbs/ft3
Cement Type	ASTM C150 Type V (Sulphate Resistant Concrete)

PART 3 -- EXECUTION

3.01 INSPECTION

- A. Prior to commencing installation, the Installer shall inspect all areas and conditions within which Work of this Section will be performed. Dimensions and clearances shall be verified. Final grading shall be completed and all earth, brush, or other obstructions which interfere with the proper alignment and construction of fencing shall be removed.

3.02 INSTALLATION

A. General

1. Fencing and gates shall be installed in accordance with ASTM F567.
2. Unless otherwise indicated, all posts shall be set in concrete. Gate and related posts, corner posts, and other critical elements shall be provided with concrete foundations.

B. Excavation

1. Holes for post footings shall be drilled to the diameters, depths, and spacings indicated on the drawings, in firm, undisturbed or compacted soil.
2. Remove and dispose excavated soil from the Work Site.

C. Setting Posts

1. Space line post footings at a maximum of 10 feet on center and parallel to the ground slope

2. Posts shall be set plumb and shall be centered in holes, 4 inches above the bottom of the excavation, with posts extending not less than 36 inches below finish grade surface. Set posts deeper, as required, in soft and problem soils and for heavy, lateral loads.
3. Corner posts shall be installed where changes in the fence lines equal or exceed 10 degrees, measured horizontally.
4. Each post shall be properly aligned vertically. Posts shall be maintained in proper position during placement and finishing operations.

D. Concrete

1. Concrete for footings may be placed without forms, providing the ground is firm enough to permit excavation to neat line dimensions. Prior to placing concrete, the earth around the hole shall be thoroughly moistened.
2. Encasement concrete for footings shall be placed immediately after mixing in a manner such that there will be no concentration of the large aggregates. The concrete shall be consolidated by tamping or vibrating.
3. Concrete shall cure for a minimum of 7 days prior to installation of fence fabric or barbed wire.

E. Bracing

1. Bracing shall be provided at all ends, corners, gates, and intermediate brace posts. Corner posts and intermediate brace posts shall be braced in both directions. Horizontal brace rails shall be set midway between the top rail and the ground, running from the corner, end, intermediate brace or gate post to the first line post. Two diagonal tension members shall connect tautly between posts below horizontal braces.
2. Where straight runs of fencing exceed 500 feet (150 metres), intermediate brace posts shall be installed, spaced equally between ends or corners; with additional posts provided as required. Intermediate brace posts shall be equivalent in size to corner posts and shall be braced with horizontal brace rails and diagonal tension members in both directions.

F. Top Rails

1. Top rails shall be run continuously through post caps, bending to radius for curved runs. Expansion couplings shall be provided as recommended by the fencing manufacturer.

G. Center Rails

1. Center rails shall be provided where indicated. Rails shall be installed in one piece, between posts and flush with posts on fabric side, using special offset fittings where necessary.

H. Tension Wire

1. Continuous bottom tension wire shall be stretched tight with turnbuckles at end, gate, intermediate, and corner posts.

2. Tension wire shall be installed on a straight grade between posts, with approximately 2 inches (50 mm) of space between finish grade and bottom selvage, unless otherwise indicated.
3. Tension wire shall be tied to each post with not less than 6 gauge galvanized wire. Tension wire shall be interlaced with the fabric or attached to the fabric along the extreme bottom of the fence.

I. Fabric Installation

1. Chain-link fabric shall be fastened on the secured side of the posts.
2. Fabric shall be stretched and securely fastened to posts. Between posts, top and bottom edges of the fabric shall be fastened to the top rail and bottom tension wire, respectively.
3. Fabric shall be stretched and anchored in such a manner that it remains in tension after the pulling force is released.

J. Tie-Wires

1. Tie wire shall be bent to conform to the diameter of the pipe to which it is attached, clasp pipe and fabric firmly with ends twisted at least two full turns. Ends of wire shall be bent back to minimize hazard to persons or clothing.
2. Fabric shall be tied to line posts with tie wires spaced at 12 inches (300 mm) on center.
3. Fabric shall be tied to rails and braces with tie wires spaced at 24 inches (600 mm) on center.
4. Fabric shall be tied to tension wires, with hog rings spaced 24 inches (600 mm) on center.

K. Tension (Stretcher) Bars:

1. Fabric shall be fastened to end, corner, intermediate brace, and gate posts with tension (stretcher) bars. Bars shall be threaded through or clamped to fabric at 4 inches on center and secured to posts with tension (stretcher) bar bands, spaced no more than 14 inches on center.

L. Fasteners

1. Nuts for tension bands and hardware bolts shall be installed on the side of fence opposite the fabric side. Ends of bolts shall be peened or the threads scored to prevent removal of nuts.

M. Touch Up

1. Clean damaged galvanized surfaces with wire brush removing loose and cracked coatings. Apply two coats of organic zinc-rich paint to damaged areas.
2. Damage to PVC coating shall be repaired with material equivalent in color and thickness to the original coating.

3.03 GATES INSTALLATION

- A. Install gates plumb, level, and secure, with full opening without interference. Install ground set items in concrete for anchorage as recommended by the fence manufacturer. Adjust hardware for smooth operation and lubricated where necessary.
- B. Gates and gateposts shall be installed in accordance with ASTM F567 and manufacturer's recommendations.
- C. Gates shall be plumb in the closed position having a bottom clearance of 3 inches (76 mm).
- D. The opening space between the hinge or latch from the gate frame shall not exceed 3 inches (75 mm) in the closed position.
- E. Direction of swing for double swing gates shall be outward.
- F. Gate stops for double gates shall be set in a concrete footing, with minimum 6 inch diameter and 24 inch deep.
- G. Class 1 external cantilever slide gates shall be furnished with roller guards and guide posts, in accordance with ASTM F1184.

3.04 GROUNDING

- A. Fences crossed by powerlines of 600 volts or more shall be grounded at or near the point of crossing and at distances not exceeding 150 feet on each side of the crossing.
- B. Fences, gates and appurtenances enclosing electrical equipment areas, gas yards, or other hazardous areas shall be electrically continuous and grounded.
- C. Ground conductor shall consist of No. 8 AWG solid copper wire. Grounding electrodes shall be 3/4-inch by 10-foot long copper-clad steel rod. Electrodes shall be driven into the earth so that the top of the electrode is at least 6-inches below grade.
- D. Where driving is impracticable, electrodes shall be buried a minimum of 12 inches deep and radically from the fence. Top of electrode shall be not less than 2 feet or more than 8 feet from the fence.
- E. Ground conductor shall be clamped to the fence and electrodes with bronze grounding clamps so as to create electrical continuity between fence posts, fence fabric, and ground rods. After installation, the total resistance of fence to ground shall not be greater than 25 ohms.

END OF SECTION

SECTION 32 92 00 – TURFS AND GRASSES

GENERAL

1.01 THE SUMMARY

- A. The Contractor shall apply grass seeding, fertilizing, watering, mulching, maintenance and inspection complete and in place, in accordance with the Contract Documents.

1.02 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

A. Reference Specifications

01 33 00	Contractor Submittals
31 30 00	Earthwork Methods

B. Federal Specifications

FS O-F-241D	Fertilizer, Mixed, Commercial (USA)
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C. Reference Standards

ANSI/ASTM D 422	Method for Particle-Size Analysis of Soils
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1.03 CONTRACTOR SUBMITTALS

- A. Furnish submittals in accordance with Section 01 33 00 – Contractor Submittals for approval.
- B. Materials List: A list of all materials to be used in the sodding and seeding operations together with the source of those materials. The list shall include, at minimum:
1. mulches,
 2. tackifier,
 3. soil amendments,
 4. fertilizers,
 5. seed mixtures and seed certificates, and
 6. erosion control blanketing.
- C. Manufacturer's literature showing physical characteristics, application methods, and installation instrumentation shall be included.
- D. Schedules: The following work plans, before work is started.
1. Delivery schedule at least 10 days prior to the intended date of the first delivery.

2. Pesticide Treatment Plan, giving proposed sequence of pesticide treatment work before work is started. The pesticide trade name, chemical composition, formulation, concentration, application rate of active ingredients and methods of application for all materials furnished, and the name and Ohio license number of the Ohio certified applicator shall be included.
3. Seeding and Sodding Operation. A list of seeding and mulching equipment to be used in performance of Seeding and Sodding operation, descriptive data, and calibration tests. Typical application methods are as follows:
 - a. Mechanical dry seeding: seed uniformly distributed on prepared growing medium at finished grade by calibrated mechanical equipment.
 - b. Hydraulic seeding (hydro-seeding): seed mixed with water, fibre mulch, fertilizer and other additives in slurry and uniformly distributed on prepared finished grade by spraying the calibrated mixture.
 - c. Integrated growing medium/seed application (terraseeding/drill seeding): seed mixed with growing medium and applied by 'blowing' the growing medium/seed mix onto a prepared subgrade or growing medium bed. This method usually applied approximately (2") depth of growing medium/seed. Where approved, the mix may be applied directly over prepared subgrade.
4. Plant Establishment Period. Written calendar time period for the beginning of the plant and sodded and seeded area establishment period. When there is more than one establishment period, the boundaries of the planted and sodded and seeded areas covered for each period shall be described.

E. Reports

1. Certified reports of inspections and laboratory tests, prepared by an independent testing agency, including analysis and interpretation of test results. Each report shall be properly identified. Test methods used and compliance with recognized test standards shall be described.
2. Reports for the following materials shall be included.
 - a. Topsoil: For pH, chemical analysis, mechanical analysis and particle size.
 - b. Fertilizer: For chemical analysis and composition percent.
 - c. Pesticide Material: For EPA registration number and registered uses or per Pest Control Products Act and Regulation (Canada)
 - d. Seed and seed mixes: Certificates shall be a maximum of 2 years old and shall specify all contents of the seed lot, including:
 - 1) list of contaminants, percentage of pure live seed (PLS), and shall have zero tolerance for noxious weed species (as defined by the applicable authority).
 - 2) All seeds and/or the entirety of the mix shall be free of disease, weed seeds, or foreign matter, minimum germination of 75%, minimum purity of 97% and conforming to the mixes specified.

- 3) All seed must be from a recognized seed firm, meeting the requirements for the Federal Seed Act. Seed shall be certified No. 1 grade.
 - 4) An additional germination test and/or weed seed analysis may be requested and all lawn seed must comply with federal and state or provincial seed laws.
- e. Sod: For species, mixture percentage, percent purity, field location and federal and/or local certification.
- 1) The supplier shall provide, upon request, a label or statement certifying the quality of grade, location of sod source and species of grass in the sod to verify that the sod meets the specification and project requirements.
 - 2) The Contractor shall retain labelling for inspection by owner or consultant.
- f. Soil analysis for horticultural use shall include results for existing major soil nutrients, soil pH value, total soluble salts (electrical conductivity), percentage of organic matter, soil texture, and percentage of sand, silt and clay, nutrient recommendations, and recommendations for soil amendments.

1.04 CERTIFICATES: CERTIFICATES OF COMPLIANCE THAT MATERIALS MEET THE INDICATED REQUIREMENTS PRIOR TO THE DELIVERY OF MATERIALS.

A. Records:

1. Plant Establishment Period
2. Maintenance Report
3. Maintenance Instructions

1.05 HANDLING AND STORAGE

A. Grass Seed

1. All grass seed, nurse crop seed, and hydromulch shall be stored in original containers or packaging until such time as accepted by Engineer.
2. All seed shall be stored in a suitable dry, weatherproof storage place.
3. All seed shall be protected from damage by heat, moisture, invasive, and noxious plant seed contamination, rodents, or other damaging or contaminative causes until time of seeding.
4. Labels or other identification shall not be removed from containers or packaging or be defaced.

B. Sod

1. Sod shall not be dropped or dumped from vehicles.
2. Sod shall be protected during transportation against wind exposure to prevent drying and shall arrive at the site in a fresh and healthy condition.

3. Where there is any delay in installation, the sod shall be kept moist, cool, and protected against adverse weather conditions at all times until installation.
4. During the growing season, and where feasible, sod should be delivered to the site within 36 hours of harvest and shall be installed within 24 hours of delivery.
5. During the growing season, and where feasible, sod should be delivered to the site within 36 hours of harvest and shall be installed within 24 hours of delivery.
6. Sod shall be allowed to dry sufficiently after wet weather conditions to prevent tearing or damage during handling and installation.

1.06 CLEANUP

- A. Upon completion of all seeding/sodding operations, the portion of the Site used for a work or storage area by the Contractor shall be cleaned of all debris, superfluous materials, equipment, and garbage.
- B. Walks and pavement shall be swept or washed clean upon completion of the WORK of this Section.

1.07 MAINTENANCE OF LANDSCAPING PLANTING PRIOR TO ACCEPTANCE OF PROJECT

- A. General: The Contractor shall be responsible for protecting, watering, fertilizing, and maintaining sodded and seeded areas until final acceptance of the WORK.
- B. Acceptance of grass areas shall be only undertaken when the following conditions are met:
 1. Growing medium quality, fertility levels, depths and surface conditions are as set out in this specification, unless specified otherwise.
 2. Grasses are of the required species.
 3. Lawn areas are relatively free of weeds and invasive plants, containing no more than 5 broadleaf weeds or 25 annual weeds or weeds grasses per 1,080 sq.ft² / 120sq.yd.
 4. Grasses shall be uniformly established in sufficient density such that 80% of the surface growing media shall be visible when they are mown to a height of 60mm / 2.5in.
 5. Seed:
 - a. If seed fails to germinate within four growing months, re-cultivate and re-seed until germination takes place.
 - b. All seeded areas have been mown at least twice to a height of 2.5in., the last mowing being within 48 hours of the field review for acceptance.
 6. Sod:
 - a. Has been sufficiently established so that its roots are growing into the underlying growing medium.

- b. Sodded areas have been mowed at least four times to a height of 1.5in, the last mowing being within 48 hours of the field review for acceptance.
 - c. Lawns show no visible sod seams.
- C. Upon completion of seeding/sodding, the entire planted area shall be watered until the topsoil has been saturated by a fine spray to depth of 2 inches. The new planting shall be kept watered by the sprinkling system on the Site during dry weather or whenever necessary for proper establishment of the sodded and seeded areas. Care shall be taken to avoid excessive washing or puddling on the surface and any such damage caused thereby shall be repaired by the Contractor.
- D. Protection: The Contractor shall provide adequate protection to all newly seeded/sodded areas including the installation of approved temporary fences to prevent trespassing and damage, as well as erosion control, until the end of the one-year correction period.
- E. The Contractor shall replace any materials or equipment it has damaged, or which has been damaged by its employees or subcontractors.
- F. Partial utilization of the project shall not relieve the Contractor of any of the requirements of this Section
- G. Mowing of sodded and seeded areas: First mowing shall begin as soon as the grass has reached a height of 3 inches and subsequent mowing shall be at least once a week, or as often as necessary to maintain sodded and seeded areas at a uniform height of 1-1/2 to 2 inches.
- H. Sodded and seeded areas shall be fertilized every 3 weeks with 6 lbs of 16-16-16 commercial fertilizer per 1000 sq ft (2.7 kg of 19-19-19 commercial fertilizer per 100 sq metre) for the first 7 weeks and fertilized thereafter once each 5 months prior to acceptance and during maintenance and correction period.
- I. Maintenance shall include, in addition to the foregoing, cleaning, edging, the repair of erosion, and other maintenance work. Sidewalks and other paved areas shall be kept clean while planting and maintenance are in progress.

1.08 FINAL INSPECTION AND GUARANTEE

- A. Inspection of seeded/sodded areas will be made at final acceptance
- B. Written notice requesting inspection shall be submitted to the Engineer at least 10 days prior to the anticipated inspection date.
- C. Any delay in completing the Work of this Section beyond a single season will be cause for extending the correction of defects period an equal time.
- D. The Contractor shall, without additional expense to the Owner, replace seeding and sodding which develops defects or dies during the correction period.

PART 2 -- PRODUCTS

2.01 GENERAL

- A. Materials for soil conditioning and weed abatement shall be first-grade, commercial quality and shall have certificates indicating the source of material, analysis, quantity, or weight attached to each sack or container or furnished with each delivery. Delivery certificates shall be given to the Engineer as each shipment of material is delivered. A list of the materials used, together with typical certificates of each material, shall be submitted to the Engineer prior to final acceptance.

2.02 GRASS SEED

- A. Grass seed shall meet the requirements of the applicable federal and local requirements.
- B. Seed mixtures shall be suited to the climate, growing medium condition and type, site orientation, sun exposure, terrain, purpose of use, establishment and lawn class designation under which they are to be grown and/or to this specification.
- C. Seed shall have minimum germination rate of 75% and minimum purity of 97%, except where otherwise approved.
- D. Seed shall be packed and delivered in original containers in accordance with the applicable Seeds Act and/or jurisdiction, clearly showing:
 - 1. Name and address of supplier, packager, or labeler.
 - 2. Name of the kind or species of seed.
 - 3. Name of the grade of seed.
 - 4. Varietals name of the seed.
 - 5. Lot number.
 - 6. Germination % age.
 - 7. Purity analysis of seed mixture, % age of pure seed, variety and weed.
 - 8. Year of production.
 - 9. Net weight (mass).
- E. The seed mixture shall be mixed, labeled, and supplied by a recognized seed supplier.
- F. The installer shall retain package labels and seed sample for inspection by owner.
- G. Hydroseed:
 - 1. Hydromulch shall contain no growth or germination inhibiting factors, be dry, free of invasive plants and all other foreign materials.
 - 2. Hydromulch shall be supplied in packages bearing the manufacturer's label clearly indicating weight and product name.

3. Fiber should be green colored fibrous, wood cellulose mulch, not containing any growth or germination inhibitors, and shall be manufactured so that it will form uniformly suspended homogeneous slurry when added to the fertilizer, seed and water in a tank and agitated. Composition on airdry weight basis: 9 to 15 percent moisture and pH range from 4.5 to 6.0.
 4. Hydraulic mulch may contain a colloidal polythacuride (or equivalent) industry accepted tackifier for adhesion on slopes as erosion control and to prevent chemical agglomeration during mixing in hydraulic mulching equipment.
 5. When used on slopes or erodible surfaces, hydraulic mulches shall contain a binder that is able to join seed and soil particles together until turf growth is established. The binder and mulch shall form a pervious mat or matrix which will not prevent the penetration of moisture to the underlying soil.
 6. Erosion control products include blown hay or straw, wood fiber combined with tackifier, Erosion Control Blanket, Stabilized Mulch Matrix (SMM), Bonded Fiber Matrix (BFM), and Flexible Growth Medium (FGM). Mulch shall be crimped into soil with a mulch crimper. Spacing on the blades of the mulch crimper shall be 6-inches minimum and 9-inches maximum. Blades shall be sufficiently weighted to penetrate the ground 3-inches.
- H. Seed mixture shall be in accordance with the seed mix currently used by the City of Warren. Any deviation of the indicated seed mixture composition shall be approved by the Engineer prior to delivery to the Site.

2.03 SOD

- A. All sod shall be suited to the locality, site conditions, and intended function of each project or area, and specification.
- B. The sod shall be relatively free of thatch, diseases, nematodes, soil-borne insects, weeds or undesirable plants, stones larger than 1-inch (25mm) in any dimension, woody plant roots and other material detrimental to a healthy stand of turf. Sod that has become dry, moldy, or yellow from heating, or has irregularly shaped pieces of sod and torn or uneven ends shall be rejected.
- C. Sod shall be machine cut by machines designed for that purpose, to a uniform thickness of 1-1/4 inches (33mm) within a tolerance of 1/4 inch (6mm), excluding top growth and thatch. Measurement for thickness shall exclude top growth and thatch. Broken pieces and torn or uneven ends shall not be acceptable.
- D. Sod shall contain at least 85 percent permanent grass suitable to the climate in which it is to be placed; not more than 25 percent nursing grass; not more than 10 percent weed and undesirable grasses, and shall be of good texture, free from obnoxious roots, stones and foreign materials.
- E. Sod shall have a fibrous root system strong enough that a standard sized section can support its own weight without damage or tearing when suspended vertically by holding up the upper two corners.
- F. Sod shall not be harvested or transplanted when excessive moisture or dryness will result in damage to, or failure of the sod.

- G. The height of the grass in the sod at the time of harvesting shall be between 40mm / 1.5in and 60mm / 2.5in except where otherwise specified.
- H. 13mm / 0.5in of thatch (uncompressed) is acceptable.
- I. Sod shall be reasonably free from visible diseases, detrimental fungi and damaging nematodes, and soil-born insects, to the extent that with installation methods and establishment maintenance, new turf will not deteriorate due to such causes.
- J. Weeds, invasive and noxious plants:
 - 1. All sod shall be free from plants designated as noxious weeds by the Federal and/or regulatory authority.
 - 2. Nursery sod shall be free of broadleaf weeds, invasive species, and undesirable grasses to the extent required for each quality grade.
 - 3. Field sod shall contain no more than 10 weeds per 10m² / 100 sq.ft².

2.04 WATER

- A. Water used in hydraulic seeding and irrigation shall be free of any impurities that may have an injurious effect on the success of seeding or germination or may be harmful to the environment.
- B. Irrigation shall be scheduled to meet the needs of all phases of the project.

2.05 TOPSOIL

- A. Topsoil shall be the existing soil stripped to the depth indicated and stockpiled at a location directed by the Engineer in accordance with Section 31 30 00 – Earthwork Methods.
- B. Growing medium shall consist of a suitable and approved homogenous blend of sand and composted organic components.
- C. Where applicable, the growing medium in the 'blown' component shall be similar in sieve analysis and organic content to the underlying growing medium such that the interface of the two materials does not impede percolation.
- D. Composted organic components shall be derived from well composted green waste organic matter produced by a composting site that meets or exceeds the requirements outlined in this specification.
- E. The growing medium/seed mix shall be homogenous with uniform distribution of mineral components organic components, seed, fertilizers and other components throughout the mix.
- F. Equipment used for integrated growing medium/seed application shall be purpose-built, with a pneumatic blower unit, and computer-calibrated seed injection system capable of simultaneously applying growing medium and seed uniformly over the whole area without significant variation in the mix.
- G. Additional topsoil, if needed, shall comply with the following:

1. Topsoil shall be obtained from naturally drained areas and shall be fertile, friable loam suitable for plant growth. Topsoil shall be subject to inspection and approval at the source of supply and upon delivery.
2. Topsoil shall be of uniform quality, free from subsoil, stiff or lumpy clay, hard clods, hardpan, rocks, disintegrated debris, plants, roots, seeds, free of disease and any other materials that would be toxic or harmful to plant growth. Topsoil shall contain no noxious weeds or noxious weed seeds.
3. Topsoil shall contain at least 6 percent organic matter as determined by loss of weight after ignition of dried (moisture-free) samples in accordance with current methods of the Association of Official Agricultural Chemists.
4. The acidity range of the topsoil shall be (pH 5.5 to pH 7.5). The salinity level shall be less than 3 millimhos/cm.
5. Clay, as determined by the Bouyoucous hydrometer or by the decantation method, shall not exceed 60 percent of the topsoil material.
6. Mechanical analysis shall be performed and shall conform to ASTM D 422.

H. Soil Test

1. Topsoil tests: The topsoil shall be tested for pH, particle size, salt levels, disease, chemical analysis, and mechanical analysis, by an independent commercial testing company or agency which is ISO 17025 certified Laboratory. The soil samples for the soil tests shall be of a quantity and locations so an accurate soil test representative of the soil(s) can be performed. The independent testing company or agency shall outline the soil testing procedures. The Engineer will have the right to be present at the time the samples are taken.
2. Topsoil recommendation: The independent test company performing soil test shall establish the quantities and type of soil amendments and fertilizer (initial and maintenance) that the Contractor shall add to topsoil. The Contractor shall obtain approval of topsoil and soil amendments by the Engineer prior to the beginning of work.

2.06 FERTILIZER AND ADDITIVES

- A. Fertilizer shall be furnished in bags or other standard containers with name, weight, and guaranteed analysis of contents clearly marked thereon.
- B. Chemical fertilizers shall be a mixed commercial fertilizer conforming to Federal Fertilizers Act and Regulations (FS O-F-241D) and ODOT Item 659.04, with percentages of nitrogen, phosphoric acid, and potash at 12-12-12. Fertilizers shall be uniform in composition, dry, and free flowing.
- C. Fertilizer containers shall not exceed 50 pounds (22.6 kg) each.
- D. Compost Material (USA):

1. Compost shall be a well decomposed, stable, weed free organic matter source. It shall be derived from: agricultural, food, or industrial residuals; biosolids (treated sewage sludge); yard trimmings; source-separated or mixed solid waste. The product shall contain no substances toxic to plants and shall be reasonably free (< 1% by dry weight) of man-made foreign matter. The compost will possess no objectionable odors and shall not resemble the raw material from which it was derived. For acid loving plants, only use compost that has not received the addition of liming agents or ash by-products. The product shall be certified through the U.S. Composting Council's (USCC) Seal of Testing Assurance (STA) Program.

E. Lime shall conform to ODOT 659.03.

F. Agricultural gypsum shall be approved standard brand agricultural calcium sulfate (CaSO_4) as applied to soils and shall contain 19 percent combined sulfur.

2.07 EROSION CONTROL MATERIAL

A. Soil Erosion Control Blanket: Blanket shall be machine-produced mat of wood excelsior formed from a web of interlocking wood fibers, covered on one side with either knitted straw blanket-like mat-construction, covered with biodegradable plastic mesh, or interwoven with biodegradable thread, plastic netting or twisted kraft paper cord netting.

B. Soil Erosion Control Fabric: Control fabric shall be knitted construction of polypropylene yarn with uniform mesh openings of 314 per 1-inch square with strips of biodegradable paper. Filler paper strips shall last 6 to 8 months.

C. Soil Erosion Control Net: Control net shall be heavy, twisted jute mesh weighing approximately 1.22 pounds per linear yard and 4-feet wide with mesh openings of approximately 1-inch square.

D. Anchors: Erosion control anchors shall be as recommended by the manufacturer.

2.08 PESTICIDE

A. Pesticide shall be insecticide, herbicide, fungicide, nematocide, rodenticide, and miticide. Pesticide material shall be labeled for use and applied only as registered by EPA and approved. The applicator shall be certified within local regulations to apply pesticides. The applicator shall be certified within local regulations to apply pesticides. Applicator must provide document of certification minimum of 2 weeks to ENGINEER for review prior to application.

B. Herbicide shall contain glyphosate as an active ingredient and must follow regulation per US EPA. The herbicide shall not contain a surfactant. The herbicide shall allow seeding/sodding to take place 3 days after application of the herbicide. The applicator shall be certified within local regulations to apply herbicides. Applicator must provide document of certification minimum of 2 weeks to Engineer for review prior to application.

PART 3 -- EXECUTION

3.01 GENERAL

- A. Delivery of seed and fertilizer may begin only after samples and tests have been approved by the Engineer. Seed and fertilizer furnished shall not be different from the approved sample.
- B. Work shall not be performed at any time when it may impede establishment success by climatic conditions.

3.02 SOIL PREPARATION

- A. The seeding shall not begin until the Contractor has repaired all areas of settlement, erosion, rutting, etc. and the soils have been placed, compacted, and contoured to finish grade. The Engineer shall be notified of areas that prevent the planting work from being executed.
- B. After removal of waste materials in the planting areas, such as weeds, roots, rocks 2-inches and larger, construction materials, etc., the seeding subgrade shall be scarified and pulverized to a depth of not less than 6-inches and all surface irregularities removed.
- C. Areas requiring grading by the Contractor including adjacent transition areas shall be uniformly level or sloping between finish elevations to within 0.10-ft above or below required finish elevations.
- D. Any unusual subsoil condition that will require special treatment shall be reported to the Engineer.
- E. Topsoil: Topsoil shall be distributed uniformly and spread evenly to a minimum thickness of 4 inches on subgrade for sodded and seeded areas. Subgrade shall be ripped or disked to a depth of 8- to 12-inches. Topsoil shall be spread so that planting can proceed with little additional soil preparation or tillage. Topsoil shall not be placed when the subgrade is frozen, excessively wet, extremely dry, excessively compacted or in a condition detrimental to the proposed planting or grading.
- F. Fertilizer: Fertilizer shall be applied at the rate of 400 pounds per acre. Fertilizer shall be incorporated into the soil to a minimum depth of 4 inches and may be incorporated as part of the tillage or hydroseeding operation.
- G. Tillage
 - 1. Preparation. Sodded and seeded areas shall be filled as needed or have surplus soil removed to attain the finished grade. Drainage patterns shall be maintained as indicated on drawings. Turf areas compacted by construction operations shall be completely pulverized by tillage.
 - 2. Area Debris. Sodded and seeded areas shall have debris and stones larger than 1-inch in any dimension removed from the surface.
 - 3. Protection. Finished graded areas shall be protected from damage by vehicular or pedestrian traffic and erosion.

4. Finish Grading. Finished grade shall be 1-inch below the adjoining grade of any surfaced area. New surfaces shall be blended to existing. Make minor adjustments of finish grades as directed by the ENGINEER.

3.03 APPLICATION OF PESTICIDE AND HERBICIDES MATERIAL

- A. When pesticide and herbicides become necessary to remove a disease or pest, a state (provincial) certified applicator shall apply required pesticide in accordance with State EPA label restrictions and recommendations. Hydraulic equipment for the liquid application of pesticides shall consist of a leakproof tank, positive agitation methods, controlled application pressure, and metering gauges. A pesticide treatment plan shall be furnished to the Engineer as indicated above. The applicator shall be certified within local regulations to apply pesticides and herbicides. The applicator shall be certified within local regulations to apply pesticides and herbicides. Applicator must provide document of certification minimum of 2 weeks to Engineer for review prior to application.

3.04 SEEDING

- A. Seeding shall be carried out during periods when seasonal conditions provide successful germination and continued growth of all species of seed in the grass mix.
- B. All seeding shall be conducted during calm weather, and is not permitted;
 1. when wind velocity exceeds 6 mph,
 2. during periods of moderate to heavy rainfall and within 4 hours after rain, or
 3. when the surface has been compacted without first loosening the ground, or
 4. when the ground is not free of frost, snow, or standing water.
- C. Seed shall be applied by Mechanical Dry Seeding, hydroseeding, or terraseeding/drill seeding, unless otherwise specified.
- D. Hand seeding shall only be carried out when patching limited areas of lawns or where site conditions preclude the above methods.
- E. Rates of Application
 1. Rates of application of seed species mixtures, hydromulch and other components shall be based on an analysis of the season, climate, terrain, growing medium, and establishment, and maintenance conditions and intended use of lawn.

3.05 MECHANICAL BROADCAST DRY SEEDING

- A. Broadcast seeding shall be performed where indicated or as directed in the field by the Engineer.
- B. The soil shall be prepared per soil preparation instructions. The Engineer will inspect and approve the soil preparation prior to commencing with seeding and fertilizing. The Contractor shall prepare only enough ground that can be planted within 24 hours thereafter.

- C. Fertilizer shall be evenly applied to the prepared ground at a rate of 350 pounds per acre. Fertilizing shall be completed prior to seeding.
- D. Sow seed at the application rates indicated above. Equal quantities of seed shall be sown in two directions at right angles to each other to produce an even distribution of seed over the entire area.
- E. The seed shall then be covered with a fine layer of soil to a depth not greater than 1/4-inch.
- F. Critical areas within 12-feet of streams or other water bodies shall be mechanically or hand raked to cover seed prior to mulching or installation of erosion control fabric. ENGINEER may designate in the field other areas that require raking.
- G. Flat, seeded areas shall be evenly covered with a weed-free straw mulch at the rate of 2,000 pounds per acre. Areas with slopes steeper than 4 horizontal to 1 vertical shall be covered with the indicated erosion control matting.
- H. Broadcast seeding method shall be utilized between August 15 to October 30. If necessary to seed before August 15 but after March 1 increase the seeding rates by 5 percent (Refer to Item 659 of ODOT 2023 CMS).
- I. Mechanical application (hydroseeding) is acceptable. The CONTRACTOR shall notify the ENGINEER of proposed method, mulch, and type of equipment to be used and shall receive approval before beginning this operation.

3.06 HYDROSEEDING

- A. General: Areas labeled seeded shall be hydroseeded or drill seeded if flat and larger than 1/2 acre or (0.2 hectare).
- B. Equipment: Mixing shall be performed in a tank. The tank shall have a built-in continuous agitation and circulation system, of sufficient operating capacity to produce a homogenous slurry of mulch, stabilizer, seed, fertilizer and water in the designated unit proportions for a minimum coverage of one-half acre. The tank shall have a discharge system which will permit attachment of at least 500-feet of hose extensions, a change of elevation of 150-feet in height from tank to discharge nozzle, and still retain enough pressure to apply the slurry to the areas at a continuous and uniform rate.
- C. Proportions: Proportions per acre shall be as follows:
 - 1. Mulch, 2,500 pounds
 - 2. Seed, proportioned to mixture of seed as specified herein
 - 3. Stabilizer, 120 pounds
 - 4. Fertilizer, 350 pounds
 - 5. Water, 3,000 gallons
- D. Application

1. With agitation system operating at part speed, water shall be added to the tank and good recirculation shall be established. Materials shall be added in such a manner that they are uniformly blended into the mixture.
2. When the tank is 1/3 filled with water, add the following materials in the sequence listed:

Sequence	Material
1	Stabilizer, 1/2 acre requirement
2	Three 50 pounds bales mulch
3	Seed, 1/2 acre requirement
4	Fertilizer, 1/2 acre requirement

- a. Agitate mixture at full speed when the tank is half filled with water.
- b. Add remainder of mulch requirement before tank is 3/4 full.
- c. Slurry distribution shall begin immediately. Application of slurry shall be done only when rain is not anticipated for at least three days after slurry application.
- d. The entire tank of each batch of slurry shall be emptied and the slurry evenly applied to areas to be hydroseeded within a 2-hour period following the mixing of each slurry batch. Slurry batches not applied during this time will be rejected.
- e. When applied, the hydromulch shall be applied uniformly and in such a manner as to prevent pooling and movement of the growing medium surface and be capable of forming an absorptive mat which will allow moisture to percolate into the underlying soil.

3.07 DRILL SEEDING (TERRASEEDING)

- A. Flat areas larger than 1/2 acre in size that are designated for seeding in the Contract Documents shall be seeded by drilling.
- B. Prior to application of growing medium and seed, the pneumatic blower shall be calibrated to provide the specified amounts and proportions of growing medium and seed.
- C. Growing medium/seed mix shall be applied to a uniform depth over the whole area.
- D.
- E. Seeding: Seed shall be uniformly drilled to an average depth of 1/4- to 1/2-inch at the rate specified using equipment having drills not more than 6 inches apart. Row markers shall be used with the drill seeder. Drill seeding shall take place 3 days after application of herbicide.
- F. Except where otherwise specified or instructed, the growing medium and seed shall cover the entire area and overlap adjoining ground by 1ft.
- G. Existing site equipment, roadways, landscaping, reference points, monuments, markers and structures shall be protected from over-spray damage.

- H. Over-spray or damage that occurs shall be documented, reported, and promptly rectified.
- I. Rolling: Immediately after seeding, the entire area shall be firmed with a roller not exceeding 90 pounds for each foot of roller width. Areas seeded with drills equipped with rollers shall not be rolled.
- J. Water: Watering shall be started within 4 days after completing the seeded area. Water shall be applied at a rate sufficient to ensure moist soil conditions to a minimum depth of 2 inches. Run-off and puddling shall be prevented.

3.08 SOD PLACEMENT

- A. Sodding Period: Sod laying shall be performed during the active growing season for the type of sod. Sod installed during dry periods, at freezing temperatures, or over frozen growing medium shall not be accepted.
- B. Sod shall be installed within 24 hours of delivery, and within 36 hours of harvest, unless otherwise authorized and a suitable preservation method is approved prior to delivery.
- C. Sod not installed within 36 hours of harvesting or within 24 hours of delivery may be rejected if there is any evidence of deterioration.
- D. The Contractor shall coordinate sod laying with growing media operations and with the installation of irrigation and lighting systems.
- E. Preparation of grade
 - 1. Where the growing medium surface is dry, it shall be lightly moistened immediately before laying the sod. Adequate soil moisture shall be ensured prior to sodding by spraying water on the area to be sodded and wetting the soil to a minimum depth of 1 inch.
 - 2. Sites requiring sodding shall be prepared to meet the requirements set out in this Specification.
- F. Sod shall be laid in smooth even staggered rows, and closely knit together in such a manner that no open joints wider than 1/8in. are visible, joints are staggered a minimum of 10in. and no pieces are stretched or overlapped.
- G. Sod shall be laid smooth and flush with adjoining grass areas, paving and top surface of curbs unless shown otherwise on the drawings.
- H. New sod shall be protected from heavy foot traffic during and after laying. Suitable protection in the form of broad planks and plywood shall be placed, if necessary, to prevent damage to sod, as well as growing medium grade and level.
- I. Sod shall be cut where necessary only with a sharp knife or edging tool.
- J. The sodded area shall be rolled, tamped, or planked with plywood providing sufficient pressure, to provide a good bond between sod and growing medium.

- K. As sodding is completed in any one section, the section shall be lighting rolled and then irrigated immediately with sufficient amounts of water to thoroughly moisten the sod and the growing medium to prevent drying. The sod shall be irrigated immediately with sufficient amounts of water to thoroughly moisten the sod and the growing medium to prevent drying. The sod shall be irrigated as required in order to maintain a moist root zone. The amount of water required will vary depending upon season, weather, temperature, wind, slope, and sod variety. The Contractor shall be responsible for having adequate water available at the site prior to, and during, installation.
- L. On long slopes, with grades greater than 2:1, sod shall be laid at right angles to slopes or the flow of water. Sodding shall start at the bottom of the slope and shall be laid crosswise and staggered on the slope. Every row shall be pegged with wooden lath pegs of sufficient length to provide secure anchorage of the sod, and at intervals of not more than 1.5ft.
- M. In ditches, sod shall be laid at right angles to the flow of water.
- N. When required, the sod shall be anchored by placing anchors a minimum distance of 2-feet on center with a minimum of 2 anchors per sod section. Staples shall provide secure anchorage of the sod to the ground.
- O. Before pedestrian traffic is permitted on the turf, and after the turf is well rooted into the growing medium, pegs or stakes shall be removed or driven at least 2in. below the sod surface.

3.09 EROSION CONTROL INSTALLATION

- A. Erosion control material is required on slopes greater than 4:1. Erosion control material shall be installed in accordance with manufacturer's instructions. Placement of the erosion control material shall be accomplished without damage to installed material or without deviation to finished grade.

3.10 MAINTENANCE PRIOR TO ACCEPTANCE

- A. Maintenance for seeded and sodded areas shall begin immediately after seeding or sodding has been completed and shall continue until the date set for signing off or acceptance of the area.
- B. Maintenance shall include all measures necessary to establish and maintain grass in accordance with the intended use, and in a vigorous growing condition, including, but not limited to the following:
 - 1. The first mowing shall not be attempted until:
 - a. All seed has germinated, and new grass has reached a mowing height of 3in-3.5in.
 - b. All sod is firmly rooted and securely in place.
 - 2. Mowing shall be carried out at regular intervals as required, to maintain grass at a maximum height of 2.5in for manicured areas, 3in for naturalized spaces.
 - 3. No more than 1/3 of the blade shall be cut at anyone mowing.

4. Edges shall be maintained in a neatly trimmed condition.
5. Heavy clipping that may interfere with the healthy growth of the sod shall be removed immediately after mowing and trimming.
6. Regrading, re-seeding, or re-sodding shall be carried out when necessary to restore damaged or failing grass areas.
7. Irrigation shall be scheduled and carried out when required and with sufficient quantities to prevent grass, seed, sod, and underlying growing media from drying out.
8. When environmental conditions allow:
 - a. Any seeded areas that show deterioration or bare spots shall be repaired immediately.
 - b. Any sodded areas showing shrinkage cracks shall be top -dressed and seeded with a seed mix matching the original.
9. Insect, pest, weed, and invasive plant control
 - a. Lawns shall be inspected regularly for signs of insects, disease, and invasive and weed species.
 - b. Weed control measures shall be carried out when the density of weeds reaches 25 broadleaf weeds per 1,080sq.ft2 or to an acceptable threshold for the lawn, in consultation with the Owner.
 - c. Weed control shall consist of integrated pest managements (IPM) best practices and shall reduce the density of weeds to an acceptable, established threshold for the lawn, in consultation with the Owner.
 - d. Invasive and noxious plant control measure shall reduce the density of these plants to zero.
 - e. Insect pest controls shall be timely and applied as appropriate for individual species.
 - f. Where chemical controls are used, products shall meet municipal standards and bylaws and shall be timed and applied as appropriate for individual species.

3.11 PROTECTION

- A. Temporary wire or twine fencing, barriers, barricades, signage, or other appropriate means shall be provided and maintained where required to protect newly seeded and sodded areas from damage, including but not limited to erosion, pedestrian and vehicular traffic, or wildlife.
- B. Except as required by the Contract, or as otherwise agreed, protective fencing shall be maintained in good condition until such time as the lawn has been established or until acceptance.

3.12 CLEANUP

- A. All materials and other debris resulting from seeding and sodding operations shall be removed promptly from the job site upon completion of each phase of the project.

END OF SECTION

SECTION 33 05 05.32 – GRAVITY PIPELINE TESTING

PART 1 -- GENERAL

1.01 SUMMARY

- A. The Contractor shall test sanitary system pipelines in accordance with the Contract Documents.

1.02 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

- A. Reference Specifications

01 33 00	Submittal Procedures
33 05 05.50	Pressure Pipe Testing and Disinfection

1.03 CONTRACTOR SUBMITTALS

- A. Furnish submittals in accordance with Section 01 33 00 – Submittal Procedures.
- B. Furnish:
1. A testing plan and schedule including methods for water conveyance, control, leak testing, and water disposal shall be submitted in writing for approval.
 2. Where deflection testing of flexible pipe is required, submit a method for mandrel testing or other measurement, as applicable to pipe size.

PART 2 -- PRODUCTS

2.01 DEFLECTION MANDREL

- A. Mandrel Design: The Contractor shall construct a mandrel of steel or rigid plastic which can withstand a force of 200 psi without deforming. The mandrel shall have 9 or more "runners" or legs, as long as the number is an odd number. The mandrel barrel length shall be at least 75 percent of the pipe inside diameter.
- B. Mandrel Diameter: The outside diameter shall taper out to 95 percent of the inside diameter of the pipe. For the purpose of determining the mandrel diameter, the inside diameter of the pipe shall be the average outside diameter of the pipe minus 2 X minimum wall thicknesses for OD controlled pipe and shall be the average inside diameter for ID controlled pipe, all dimensions in accordance with the respective pipe standards. Statistical or "tolerance packages" shall not be considered in mandrel sizing. The mandrel shall be stamped or engraved at a location other than a runner with the pipe size and material it is intended to test.

- C. Proving Ring: Fabricate a 1/2-inch thick, 3-inch wide steel bar bent to a circle 0.02-inches larger than the mandrel diameter calculated above. Furnish the proving ring to the Engineer before any pipe is backfilled. The Contractor shall pass the mandrel through the proving ring at times determined by the Engineer.

PART 3 -- EXECUTION

3.01 GENERAL

- A. Gravity sewer pipes and service laterals shall be tested for exfiltration or infiltration and deflection as indicated. Manholes shall be tested for leakage prior to backfill placement, whereas pipes shall be backfilled prior to testing. The maximum length of pipe tested shall be the 4 reaches between 5 manholes. Leakage tests shall be completed and approved prior to placing of permanent resurfacing of pavement. When leakage or infiltration exceeds the allowed amount, the Contractor shall locate the leaks and make the necessary repairs or replacements to reduce the leakage or infiltration to the allowable limits. Individually detectable leaks shall be repaired, regardless of whether the test results are acceptable or not.
- B. Unless otherwise indicated, water for testing will be furnished by the Owner; however, the Contractor shall convey the water from the Owner-designated source to the points of use.
- C. No materials shall be used which would be injurious to pipeline structure and future function. Air test gauges shall be laboratory-calibrated test gauges, and if required by the Engineer, shall be recalibrated by a certified laboratory prior to the leakage test. Air test gauges shall have a size and pressure range appropriate for the pipe being tested.
- D. Testing operations shall be performed in the presence of the Engineer.

3.02 TESTING SCHEDULE

A. Leakage Tests

1. Perform the type of leakage tests determined from the table below, based on pipe size, slope between manholes (Criterion 1), and difference in water levels (Criterion 2).

Nominal Pipe Size	Criterion 1		Criterion 2	
	Manhole Delta H, feet (m)		Test Water vs Ground Water Delta H, feet (m)	
	less than or equal to 10 ft (3 m)	greater than 10 ft (3 m)	greater than or equal to 4 ft (1.2m)	less than 4 ft (1.2 m)
less than or equal to 24 inches (600 mm)	See Criterion 2	Infiltration or Air		
greater than 24 inches (600 mm)	See Note 1	Exfiltration	Infiltration or Air	

Note 1. If ground water is present, perform an infiltration test or air test at the option of the Contractor; if no ground water is present, perform an air test.

2. Definitions

- a. Delta H is the difference between 2 elevations.
 - b. Manhole Delta H is the invert elevation difference in 2 adjacent manholes.
 - c. Test Water vs Ground Water Delta H is the required elevation of water surface for testing minus the average elevation of ground water adjacent to the pipe to be tested.
3. For pressure sewers and force mains, conduct water pressure tests as required by Section 33 05 05.50– Pressure Pipe Testing and Disinfection.
- B. Deflection Tests: Flexible pipe 30-inches diameter and smaller shall be tested for deflection by the mandrel test. Larger flexible pipe shall be tested by a method approved by the Engineer. Excessively deflected pipe shall be removed and replaced.

3.03 WATER EXFILTRATION TEST

- A. Each section of sewer shall be tested between successive manholes by closing the lower end and the inlet sewers of the upper manhole with stoppers or inflatable plugs. The pipe and manhole shall be filled with water to a point 4-feet above the centerline of the sewer at the center of the upper manhole; or if ground water is present, 4-feet above the average adjacent ground water level, whichever is higher.
- B. Before the test begins, water shall remain in the pipe until the concrete manholes and pipe have absorbed enough water such that the water level stabilizes, or for a minimum of 4 hours, whichever is longer. The minimum test duration shall be 4 hours.
- C. Unless indicated otherwise, the Contractor shall measure exfiltration. Measure the amount of water added to the upstream manhole to maintain the water level at the elevation set above. Compare the amount added to the allowable leakage calculated below, and if the amount added is equal to or less than the allowable amount, the tested section of the pipe has passed.
- D. The allowable leakage will be computed by the formula:

$$E = 0.000012 LD (H)^{\frac{1}{2}} \quad (E = 0.000175 LD (H)^{\frac{1}{2}})$$

Where:

E = Allowable leakage in gallons per minute of sewer tested.

L = Length of sewer and house connections tested, in feet.

D = Internal diameter of the pipe in inches.

H = Elevation difference in feet between the water surface in the upper manhole and the centerline of the pipe at the lower manhole; or if ground water is present above the centerline of the pipe in the lower manhole, the difference in elevation between the water surface in the upper manhole and the ground water at the lower manhole.

3.04 WATER INFILTRATION TEST

- A. The end of the sewer at the upper structure shall be closed to prevent the entrance of water and pumping of ground water shall be discontinued for at least 3 days, after which the section shall be tested for infiltration.
- B. The infiltration into each individual reach of sewer between adjoining manholes shall not exceed that allowed by the formula above, where H is the difference in the elevation between the ground water surface and the invert of the sewer at the downstream manhole.
- C. Unless otherwise indicated, infiltration shall be measured by the Contractor.

3.05 AIR PRESSURE TEST

- A. The Contractor shall furnish all materials, equipment, and labor for making an air test. Air test equipment shall be approved by the Engineer.
- B. The Contractor may conduct an initial air test of the sewer main line after densification of the backfill but prior to installation of the service laterals. Such tests will be considered to be for the Contractor's convenience and need not be performed in the presence of the Engineer.
- C. Each section of sewer shall be tested between successive manholes by plugging and bracing all openings in the pipe and the upper ends of all service laterals. Prior to insertion in the sewer, each plug shall be checked with a soap solution to detect any air leakage. If any leaks are found, the air pressure shall be released, and the leaks eliminated, or the plug replaced.
- D. The test of the pipe and service laterals shall be conducted in the presence of the Engineer. Testing of pipe, regardless of the pipe material, shall be performed in accordance with ASTM F 1417 - Standard Test Method for Installation of Plastic Gravity Sewer Line Using Low Pressure Air.
- E. Air pressure in the sewer line shall be increased to 4.0 psi above groundwater pressure (1.0 psi for each 2.3 feet of water elevation above the highest point of the pipe). Do not allow the pressure at any point in the pipe to reach 9 psi under any circumstances. Allow the pressure to stabilize for 5 minutes, then reduce the pressure to 3.5 psi above groundwater pressure and start the test. Stop the air release and record the decrease in pressure over time.
- F. Pass/Fail Criterion: The time taken for the pressure to decrease from 3.5 to 2.5 psi above groundwater pressure shall be equal to or greater than the time below.

Nominal Pipe Diameter, inches (mm)	Minimum Time, min: sec	Length for Minimum Time, ft	Increased Time for Longer Lengths, seconds per foot
4 (100)	3:46	597	.0380
6 (150)	5:40	398	0.854
8 (200)	7:34	298	1.520
10 (250)	9:26	239	2.374
12 (300)	11:20	199	3.418

18 (500)	17:00	133	7.692
24 (600)	22:40	99	13.674
30 (750)	28:20	80	21.366
36 (900)	34:00	66	30.768

- G. Testing criteria of pipe 12-inches and larger may be adjusted if the Engineer approves. The air pressure decrease may be 0.5 psi instead of 1.0 psi , and the corresponding minimum times will be one-half of the tabulated times.
- H. For pipe larger than 24-inches , air pressure tests may be performed on each joint. The time for the pressure to fall from 3.5 to 2.5 psi, both above groundwater pressure, shall not be less than 10 seconds regardless of pipe diameter.
- I. If the time is less than the allowable time, the pipe will be considered defective and shall be repaired and retested.

3.06 DEFLECTION TEST

A. Mandrel Test

- 1. The Engineer shall be allowed to test the mandrel with the proving ring at any time. The mandrel shall pass through the proving ring with no greater than 0.02-inch clearance, and if it does not, the mandrel will be considered defective and shall be replaced.
- 2. The Contractor shall test all flexible pipe 30-inches and smaller for deflection, joint displacement, and other obstructions by passing the mandrel through the pipe not less than 30 days after completion of the trench backfill, but prior to permanent pavement resurfacing.
- 3. Pipe with a diameter less than the mandrel will be considered defective, and the Contractor shall replace it.

B. Flexible pipes in sizes larger than 30-inches shall have deflections measured by a rigid metal bar, a rigid frame, laser profiling, or other method approved by the Engineer.

- 1. The average inside diameter shall be measured before the pipe is installed and backfilled.
- 2. Deflection is defined as the difference between vertical inside diameter in the pipe before and after installation and backfilling.

3.07 MANHOLE TEST

A. Sewer manholes shall be vacuum tested for leakage prior to backfilling. Prior to testing, manholes shall be visually inspected for obvious defects. Leaks or cracks shall be repaired to the satisfaction of the Engineer.

B. Vacuum Testing

- 1. Install the vacuum test head on top of the manhole. Install and brace sealing devices on influent and effluent pipes

2. With a vacuum pump, draw a vacuum of 10 inches of mercury, deactivate the pump, and measure the time in seconds for the vacuum to drop to 9 inches of mercury.
3. Compare the time to the table below.

Minimum Time, min: sec				
Manhole Depth, ft	Manhole Diameter, inches			
	36	48	60	72
8	0:14	0:20	0:26	0:33
10	0:18	0:25	0:33	0:41
12	0:21	0:30	0:39	0:49
14	0:25	0:35	0:48	0:57
16	0:28	0:40	0:52	1:7
18	0:32	0:45	0:59	1:13
20	0:35	0:50	1:5	1:21
22	0:38	0:55	1:12	1:30
24	0:42	0:59	1:18	1:37
26	0:46	1:4	1:25	1:45
28	0:49	1:9	1:31	1:53
30	0:53	1:14	1:38	2:1

4. If the time is less than the time in the table, the manhole is defective, and it shall be repaired and retested until it is acceptable.

END OF SECTION

SECTION 33 05 05.50 – PRESSURE PIPE TESTING AND DISINFECTION

PART 1 -- GENERAL

1.01 SUMMARY

- A. The Contractor shall test and disinfect potable water pipelines and appurtenant piping, in accordance with the Contract Documents.
- B. The Contractor shall be responsible for obtaining permits for discharging excess testing and disinfection water and dechlorination of such water if required to satisfy permit limits.

1.02 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

A. Definitions

- 1. Makeup water: The quantity of water that must be supplied into a pipeline section to maintain the specified test pressure during a hydrostatic pressure test.
- 2. Pigging: Passage of a sufficient number of pigs through a pipeline to achieve the clean conditions required.
- 3. Testing allowance: The maximum quantity of makeup water that may be added into a pipeline section undergoing hydrostatic pressure testing to maintain the specified test pressure.
- 4. Visible Leakage: The visible escape (e.g., drip, spray, stream, flow) of test liquid from the test section through components, joints, connections, appurtenances, and the like in the test section.

B. Reference Specifications

01 33 00	Submittal Procedures
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C. Reference Standards

American National Standards Institute (ANSI) / American Water Works Association (AWWA)	
ANSI/AWWA B300	Hypochlorites
ANSI/AWWA B301	Liquid Chlorine
ANSI/AWWA C600	Installation of Ductile-Iron Mains and Their Appurtenances
ANSI/AWWA C604	Installation of Buried Steel Water Pipe - 4 In. (100 mm) and Larger
ANSI/AWWA C651	Disinfecting Water Mains
ANSI/AWWA C655	Field Dechlorination
ANSI/AWWA C900	Polyvinyl Chloride (PVC) Pressure Pipe and Fabricated Fittings, 4 In. Through 60 In. (100 mm Through 1,500 mm)
AWWA Manual M9	Concrete Pressure Pipe
AWWA Manual M41	Ductile-Iron Pipe and Fittings
AWWA Manual M55	PE Pipe - Design and Installation

ASTM International (ASTM)	
ASTM F2164	Standard Practice for Field Leak Testing of Polyethylene (PE) and Crosslinked Polyethylene (PEX) Pressure Piping Systems Using Hydrostatic Pressure

1.03 CONTRACTOR SUBMITTALS

A. Furnish submittals in accordance with Section 01 33 00 – Submittal Procedures.

B. Furnish:

1. A testing plan and schedule for flushing and hydrostatic testing. This shall include all equipment to be used including but not limited to pump, metering device, pressure gauge, etc., to be used for maintaining test pressure and measuring the amount of water required to maintain test pressure; method of connection of pump to pipeline; sections of pipeline to be tested with length and size of pipe, the exact area being tested, and the valves, plugs, caps, etc., being tested against indicated; and allowable loss calculations.
2. A plan and schedule for disinfection and bacteriological testing. This shall include the form of chlorine to be used; method of chlorination; flushing locations, rates of flushing, and locations of drainage facilities; the number and frequency of samples for bacteriological tests; method of taking samples; and name of the certified bacteriological testing laboratory.
3. Resume of experienced technician shall be submitted if liquid chlorine (gas) is proposed. The method of dechlorination shall be included if chlorinated water discharges to the environment are proposed.

1.04 QUALITY ASSURANCE

A. Qualifications

1. Liquid Chlorine (Gas) Technician: Shall be familiar with the biological, chemical, and physical properties of liquid chlorine (gas) and be trained and equipped to handle emergencies that may arise.

PART 2 -- PRODUCTS

2.01 EQUIPMENT AND MATERIALS

- A. All test equipment, chemicals for chlorination, temporary valves, bulkheads, and other water control equipment, and choice of disinfectant shall be as determined by the Contractor. No materials shall be used that would be injurious to the WORK for future conveyance of potable water.
- B. Pressure Monitoring: A pressure gage or sensor accurate to within 2% of full scale, with full scale no be more than twice the test pressure and scale graduations no greater than 2% of the full scale.
- C. Chlorine for disinfection may be in the form of liquid chlorine (gas), sodium hypochlorite solution, or calcium hypochlorite granules or tablets.
 1. Liquid chlorine (gas) shall be in accordance with the requirements of ANSI/AWWA B301, and shall be used only when each of the following conditions are satisfied:

PRESSURE PIPE TESTING AND DISINFECTION

- a. Appropriate gas flow chlorinators and ejectors are used.
 - b. An experienced technician directly supervises.
 - c. Appropriate safety practices are observed to protect working personnel and the public.
2. Sodium hypochlorite (liquid form) and calcium hypochlorite (granular form or tablets) shall be in accordance with ANSI/AWWA B300.
- D. Dechlorination agents shall be in accordance with ANSI/AWWA C655.

PART 3 -- EXECUTION

3.01 GENERAL

- A. Water for testing and disinfecting water pipelines will be furnished by the Owner; however, the Contractor shall convey the water from the Owner-designated source to the points of use.
- B. Hydrostatic pressure testing shall be performed for all pressure pipelines. Potable water shall be disinfected. All chlorinating and testing operations shall be performed in the presence of the Engineer.
- C. Disposal of flushing water and water containing chlorine shall be by methods acceptable to the Engineer.
- D. Disinfection operations shall be scheduled as late as possible during the Contract Time to maximize the degree of sterility of the facilities at the time the WORK is accepted by the Owner. Bacteriological testing shall be performed by the City of Warren Water Filtration Plant or a certified testing laboratory accepted by the Owner. Results of the bacteriological testing shall be satisfactory with the state Department of Health or other regulatory agency having jurisdiction.

3.02 FLUSHING AND PIGGING

- A. Flushing is recommended prior to a pressure test to reduce the probability of foreign material causing valve-seat or hydrant-seat leakage during pressure tests. Flushing should be accomplished by partially opening and closing valves and hydrants several times under expected line pressure, with flow velocities adequate to flush foreign material out. The pipeline flow velocity shall be no less than 3.0 ft/s. The duration of the initial flushing procedure shall be continued until the discharge appears clean; however, the minimum duration shall be based sufficient that a minimum of three changes of pipeline volume occurs.
- B. For larger mains or where conditions do not permit the required flow to be discharge to waste, pigging shall be required. The Contractor shall clean the system thoroughly by pigging to remove sand, grit, gravel, stones, fluids, construction waste, and all material which would not be found in a properly cleaned pipeline. Pigging shall obtain a smooth interior pipe surface free from any material or fluid not used in cleaning.
 - 1. Provision for pig access and egress points and disposal of water and materials shall be the Contractor's responsibility.
 - 2. Pigs shall be individually marked and their location shall be controlled and monitored so that no pigs remain in the system after cleaning.

3. Pigging may be done in conjunction with initial filling for the hydrostatic test.
- C. For 24-in or larger diameter mains, an acceptable alternative to flushing is to carefully broom-sweep the main, carefully removing sweepings prior to filling and chlorinating the main. The Contractor shall address OSHA requirements for confined space prior to entering a pipeline.

3.03 HYDROSTATIC TESTING OF CONCRETE, DUCTILE IRON, PVC, AND WELDED STEEL WATER PIPELINES

A. General Requirements:

1. The Contractor shall test pipelines in sections. Sections to be tested shall be defined by isolation valves in the pipeline or, where such valves are not present, the Contractor shall install temporary bulkheads or plugs for the purpose of testing. Sections that do not have isolation valves shall be tested in approximate one-mile segments. Sections that have a zero leakage allowance may be tested as a unit.
2. The Contractor shall be responsible for ascertaining that test bulkheads are suitably restrained to resist the thrust of the test pressure without damage to or movement of the adjacent pipe. Unharnessed sleeve-type couplings, expansion joints, or other sliding joints shall be restrained or suitably anchored prior to the test to avoid movement and damage to piping and equipment.
3. The Contractor shall remove or protect pipeline-mounted devices that may be damaged by the test pressure.
4. No section of the pipeline shall be tested until field-placed concrete or mortar has attained an age of 14 days.
5. Hydrostatic testing shall be conducted in accordance with this Section and requirements of the following:
 - a. Concrete pressure pipe: AWWA Manual M9.
 - b. Ductile iron pipe: AWWA Manual M41 and ANSI/AWWA C600.
 - c. PVC pipe: ANSI/AWWA C900.
 - d. Welded steel water pipe: ANSI/AWWA C601.

B. Pre-test Procedures:

1. The test section shall be slowly filled with potable water at a rate that allows air to leave the line at the same rate as water entering the line to minimize air entrapment and potential surge pressures. The test section shall be filled from a low point.
2. Air shall be expelled completely from the test section. If permanent air vents are not located at all high points, corporation cocks shall be installed at all high points to expel any air as the line is filled with water. Following the removal of any air, the corporation cocks shall be closed and the test pressure applied.
 - a. At the conclusion of the pressure test, the corporation cocks shall either be removed and the pipe plugged or be left in place as directed by the Engineer.

3. The main valve of hydrants in the test section shall be closed.
 4. Pipe with cement-mortar linings shall be filled for a minimum of 24 hours prior to testing to allow for water absorption into the lining. Concrete pressure pipe shall be filled for a minimum of 48 hours prior to testing to allow concrete lining to be saturated.
 5. The specified test pressure shall be applied using a suitable pump connected to the pipeline.
 6. The pipeline shall be allowed to stabilize at the test pressure before conducting the hydrostatic pressure. This may require several cycles of pressurizing and bleeding trapped air prior to beginning the test.
- C. Hydrostatic Pressure Testing for Acceptance:
1. The hydrostatic test shall be of at least a 2-hr duration.
 2. The test pressure in the test section shall be as indicated in the Piping Schedule. The test pressure shall be measured at the lowest point of the test section.
 3. The test pressure shall not vary by more than 5 psi for the duration of the test. Test pressure shall be maintained within this tolerance by adding makeup water through the pressure test pump into the pipeline to return the pressure in the test section to the starting pressure.
 4. At the end of the test period, makeup water shall be added through the pressure test pump into the pipeline to return the pressure in the test section to the starting pressure.
 5. The section of pipe passes if the total amount of makeup water added during the test period and at the end of the test period does not exceed the applicable testing allowance.
- D. Testing Allowance:
1. For test sections up to 2,600 feet of pipe, the testing allowance shall be calculated based on the actual length of pipe. When the test section exceeds 2,600 feet of pipe, the testing allowance shall be that which would be allowed for 2,600 feet of pipe.
 2. If pipe with a zero leakage allowance is included in a test section, then length of pipe with a zero leakage allowance shall not be considered when calculating the testing allowance.
 3. For distribution and transmission pipelines with rubber-gasketed joints, the testing allowance shall be:
 - a. PVC and Ductile Iron Pipe: 10.5 gallons per nominal inch diameter per mile per 24 hours.
 - b. Welded Steel Water Pipeline and Concrete Pressure Pipe: 10 gallons per nominal inch diameter per mile per 24 hours.
 4. Pipelines with welded or heat-fusion joints shall have no leakage.

5. Exposed piping shall have no visible leakage and no pressure loss during the test.

3.04 HYDROSTATIC TESTING OF HDPE PIPELINES

A. General Requirements

1. The Contractor shall test pipelines in sections. Sections to be tested shall be defined by isolation valves in the pipeline or, where such valves are not present, the Contractor shall install temporary bulkheads or plugs for the purpose of testing. Sections that do not have isolation valves shall be tested in approximate one-mile segments.
2. The Contractor shall be responsible for ascertaining that test bulkheads are suitably restrained to resist the thrust of the test pressure without damage to or movement of the adjacent pipe. Unharnessed sleeve-type couplings, expansion joints, or other sliding joints shall be restrained or suitably anchored prior to the test to avoid movement and damage to piping and equipment.
3. The Contractor shall remove or protect pipeline-mounted devices that may be damaged by the test pressure.

B. Pre-test Procedures

1. The test section shall be slowly filled with potable water at a rate that allows air to leave the line at the same rate as water entering the line to minimize air entrapment and potential surge pressures.
2. Air shall be expelled completely from the test section. If permanent air vents are not located at all high points, corporation cocks shall be installed at all high points to expel any air as the line is filled with water. Following the removal of any air, the corporation cocks shall be closed and the test pressure applied.
 - a. At the conclusion of the pressure test, the corporation cocks shall either be removed and the pipe plugged or be left in place as directed by the Engineer.
3. The main valve of hydrants in the test section shall be closed.

C. Hydrostatic Pressure Testing for Acceptance

1. Pressurize the test section by gradually adding water using a suitable pump connected to the pipeline. Initially advance the pressure to 50 psi. Then the pressure shall be advanced in gradual additional until the test pressure is achieved. The test pressure shall be maintained for 3 hours to allow for pipe expansion, adding water as necessary.
2. Immediately after the 3-hour expansion period, the test pressure shall be reduced by 10 psi and the addition of water stopped. Monitor for 1 hour. If the pressure drops by less than 5 percent, then the test section of HDPE pipeline passes.

3.05 REPAIR AND RETESTING AFTER FAILING TESTS

- A. In the case of pipelines that fail to pass the leakage test, the Contractor shall determine the cause of the leakage, shall take corrective measures necessary to repair the leaks, and shall again test the pipeline, repeating as necessary until the pipeline passes.

3.06 DISINFECTING PIPELINES

- A. General: Potable water pipelines except those appurtenant to hydraulic structures shall be disinfected in accordance with the requirements of ANSI/AWWA C651 using the "Continuous-Feed Method" as modified herein. Where not practical (e.g., for large-diameter mains where the volume of water makes the continuous-feed method impractical and difficult to achieve for short segments), pipelines shall be disinfected using the "Slug Method" in accordance with ANSI/AWWA C651.
- B. Chlorination: A chlorine-water mixture shall be uniformly introduced into the pipeline by means of a solution-feed chlorinating device. The chlorine solution shall be introduced at one end of the pipeline through a tap in such a manner that as the pipeline is filled with water, the dosage applied to the water entering the pipe shall be approximately 50 mg/L. Care shall be taken to prevent the strong chlorine solution in the line being disinfected from flowing back into the line supplying the water.
- C. Retention Period: Chlorinated water shall be retained in the pipeline for at least 24 hours. After the chlorine-treated water has been retained for the required time, the free chlorine residual at the pipeline extremities and at other representative points shall be at least 25 mg/L. If testing does not demonstrate a residual of 25 mg/L or greater, the disinfection procedure above shall be repeated.
- D. Chlorinating Valves: During the process of chlorinating the pipelines, valves and other appurtenances shall be operated from closed to full open to closed while the pipeline is filled with the heavily-chlorinated water.
- E. Sampling Taps: The Contractor shall provide sampling taps as shown in ANSI/AWWA C651 or as approved by the Engineer. Taps may be made at manways and air valves to help facilitate the spacing requirement.
- F. Final Flushing: After the applicable retention period, the heavily chlorinated water shall be flushed from the pipeline until chlorine measurements show that the concentration in the water leaving the pipeline is no higher than that generally prevailing in the system or is acceptable for domestic use. Any release of chlorinated water into the environment shall comply with applicable federal, state, and local regulations and the permit requirements for the project. Dechlorination of chlorinated water being discharged to the environment shall be performed in accordance with ANSI/AWWA C655.
- G. Bacteriological Testing: After disinfection and final flushing such that typical system chlorin residuals are present, if the system operates with a residual, bacteriological testing for total coliform analysis shall be performed in accordance with ANSI/AWWA C651 and the applicable requirements of the state Department of Health or other agency having jurisdiction. The pipe shall be filled with fresh potable water and left for a period of 24 hours before any sample is collected. An initial set of samples shall be taken and then second set up samples shall be taken after a minimum of 16 hours. Each set of samples shall include a sample taken every 1,200 feet of new potable water main, plus one sample at the end of the line and at least one from each branch greater than one pipe length.
- H. Redisinfection: If the initial disinfection treatment fails to produce satisfactory bacteriological test results, the disinfection procedure shall be repeated until acceptable results are obtained.

3.07 CONNECTIONS TO EXISTING SYSTEM

- A. Where connections are to be made to an existing potable water system, the interior surfaces of all pipe and fittings used in making the connections shall be swabbed or sprayed with a minimum one percent free chlorine solution before installation. Thorough flushing shall be started as soon as the connection is completed and shall be continued until discolored water is eliminated.

END OF SECTION

SECTION 33 05 31.11 – POLYVINYL CHLORIDE GRAVITY SEWER PIPE

PART 1 -- GENERAL

1.01 SUMMARY

- A. The Contractor shall provide PVC solid wall non pressure pipe and appurtenant WORK, complete and in place, in accordance with the Contract Documents.
- B. This Section covers pipe from 4- to 60-inches diameter nominal size, for use in storm sewer, sanitary sewer, or other non-pressure sewer applications.

1.02 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

A. Reference Specifications

01 33 00	Submittal Procedures
01 77 00	Project Closeout
31 30 00	Earthwork Methods
31 23 16	Trench and Minor Structure Excavation
33 05 05.32	Gravity Pipeline Testing

B. Reference Standards

American Society for Testing and Materials (ASTM) Standards	
ASTM D1784	Rigid Poly(Vinyl Chloride) (PVC) Compounds and Chlorinated Poly(Vinyl Chloride) (CPVC) Compounds
ASTM D2321	Recommended practice for Underground Installation of Thermoplastic Pipe for Sewers and Other Gravity-Flow Applications
ASTM D3034	Type PSM Poly(Vinyl Chloride) (PVC) Sewer Pipe and Fittings
ASTM D3212	Joints for Drain and Sewer Plastic Pipes Using Flexible Elastomeric Seals
ASTM F477	Standard Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe
ASTM F679	Polyvinyl Chloride (PVC) Large-Diameter Plastic Gravity Sewer Pipe and Fittings
ASTM F1417	Test Method for Installation Acceptance of Plastic Gravity Sewer Lines Using Low-Pressure Air
American Water Works Association (AWWA) Standard	
AWWA M23	PVC Pipe – Design and Installation
AWWA C110	Ductile-Iron and Gray-Iron Fittings
AWWA C153	Ductile-Iron Compact Fittings

1.03 CONTRACTOR SUBMITTALS

- A. Submittals shall be in accordance with Section 01 33 00– Submittal Procedures.
- B. Shop Drawings: The Contractor shall submit Shop Drawings and laying diagrams of pipe, joints, bends, special fittings, and piping appurtenances

POLYVINYL CHLORIDE GRAVITY SEWER PIPE

- C. Samples: Submit samples of the pipe and flexible coupling proposed. The samples shall be clearly marked to show the manufacturer's name and product identification and shall be submitted with the manufacturer's technical data and application instructions
- D. Certificates: The Contractor shall submit manufacturer's certificate that pipe conforms to these specifications.

1.04 QUALITY ASSURANCE

- A. Testing: Materials testing shall be based upon applicable ASTM Test Methods referenced herein. Costs of such inspection and tests shall be borne by the Contractor.
- B. Mandrel Test: In addition to the requirements as specified in Section 01 74 20 - Gravity Pipeline Testing, all PVC gravity sewer pipe shall be tested for deflection and obstructions.
- C. Certificates: Manufacturer's notarized certificates of compliance shall be furnished by the Contractor.
- D. The pipe shall be subjected to the specified flattening resistance, impact resistance, and stiffness tests.

1.05 CLEANUP

- A. In addition to the requirements of Section 01 77 00 - Project Closeout, the Contractor, upon completion of backfilling and grading over trenches, shall remove excess materials and equipment from the Site.

PART 2 -- PRODUCTS

2.01 GENERAL

- A. PVC Pipe shall be continuously and permanently marked with the manufacturer's name, pipe size, and minimum pipe stiffness in psi as required in ASTM D3034 or F679
- B. Manufacturing records shall be held by the manufacturer for 2 years, covering quality control tests, raw material batch number, and other information deemed necessary by the manufacturer.

2.02 PIPE

- A. Pipe shall conform to the requirements of ASTM D3034 (4-inch to 15-inch) or ASTM F679 (18-inch to 60-inch). Material for pipe shall conform to the requirements of ASTM D1784.
- B. Pipe shall be SDR 26.
- C. The manufacturer shall test a sample from each batch according to ASTM D2444.
- D. Joints shall be gasketed push-on type conforming to ASTM D3212. Elastomeric seals for compression type joints shall conform to the requirements of ASTM F477 or ASTM F913. Joint lubricant shall be approved by the Pipe Manufacturer and shall have no detrimental effect on the gasket or pipe.

2.03 FITTINGS

- A. Fittings shall conform to the requirements of ASTM D3034 or ASTM F679. The ring groove and gasket ring shall be compatible with PVC pipe ends.
- B. The stiffness of the fittings shall be not less than the stiffness of adjoining pipe.

2.04 BEDDING MATERIAL

- A. Unless otherwise indicated, material used for pipe bedding shall conform to Section 31 30 00 - Earthwork.

2.05 FLEXIBLE COUPLINGS

- A. Flexible couplings less than 24" in diameter shall be neoprene, full-circle, clamp-on type conforming to ASTM D5926 and shall be provided with 2 stainless steel band screw-clamps to secure the coupling tightly to entering and exiting pipes. Screw-clamp hardware shall be Type 304 or Type 316 stainless steel. Neoprene material shall be suitable for sewage service.

PART 3 -- EXECUTION

3.01 TRENCHING AND BACKFILL

- A. Trench excavation and backfill shall conform to the requirements of Section 31 23 16 – Trench and Minor Structure Excavation.
- B. The minimum depth of cover over the top of the pipe shall be 36-inches unless otherwise indicated.

3.02 LAYING PIPE

- A. Pipe shall be installed in accordance with the requirements of ASTM D 2321 - Standard Practice for Underground Installation of Thermoplastic Pipe for Sewers and Other Gravity-Flow Applications and as indicated. Pipe sections shall be closely jointed to form a smooth flow line. Immediately before placing each section of pipe in final position for jointings, the bedding for the pipe shall be checked for firmness and uniformity of slope.
- B. Handling
 - 1. Handling of the PVC pipe shall be done with implements, tools, and facilities as recommended by the pipe manufacturer to ensure that the pipe is not damaged in any manner during storage, transit, loading, unloading, and installation.
 - 2. Pipe shall be inspected both prior to and after installation in the ditch and all defective lengths shall be rejected and immediately removed from the working area.
 - 3. Fittings shall be lowered into trench by means of rope, cable, chain, or other means without damage. Cable, rope, or other devices used for lowering fitting into trench, shall be attached around exterior of fitting for handling. Under no circumstances shall the cable, rope, or other device be attached through the fitting interior for handling or shall pipe or fittings be dropped or dumped into the trench.

- C. Cutting and machining of the pipe shall be accomplished in accordance with the pipe manufacturer's standard procedures. Pipe shall not be cut with a cold chisel, standard iron pipe cutter, or any other method that may fracture the pipe or will produce ragged, uneven edges.
- D. Foreign matter or dirt shall be removed from the interior of the pipe before lowering into position in the trench. Pipe shall be kept clean during and after laying. Openings in the pipeline shall be closed with watertight expandable type sewer plugs or PVC test plugs at the end of each day's operation or whenever the pipe openings are left unattended. The use of burlap, wood, or other similar temporary plugs will not be permitted.
- E. Adequate protection and maintenance of all underground and surface utility structures, drains, sewers, and other obstructions encountered in the progress of the WORK shall be the Contractor's responsibility.
- F. Where the grade or alignment of the pipe is obstructed by existing utility structures such as conduits, ducts, pipes, branch connections to main sewers, or main drains, the obstruction shall be permanently supported, relocated, removed, or reconstructed by the Contractor in cooperation with owners of such utility structures. Unless otherwise indicated, protection of existing utility structures shall be the Contractor's responsibility.

3.03 FIELD JOINTING

- A. Each pipe compression type joint shall be joined with a lock-in rubber ring and a ring groove that is designed to resist displacement during pipe insertion.
- B. The ring and the ring seat inside the bell shall be wiped clean before the gasket is inserted. A thin film of lubricant shall be applied to the exposed surface of the ring and to the outside of the clean pipe end. Lubricant other than that furnished with the pipe shall not be used. The end of the pipe shall be then forced into the ring to complete the joint.
- C. The pipe shall not be deflected either vertically or horizontally in excess of the printed recommendations of the manufacturer of the coupling.
- D. Fittings shall be carefully connected to pipe, and joint shall be checked to ensure a sound and proper joint.
- E. When pipe laying is not in progress, the open ends of the pipe shall be closed to prevent trench water from entering pipe. Adequate backfill shall be deposited on pipe to prevent floating of pipe. Any pipe that has floated shall be removed from the trench, cleaned, and re-laid in an acceptable manner. No pipe shall be laid when, in the opinion of the Engineer, the trench conditions or weather are unsuitable.

3.04 TESTING

- A. The internal diameter of the pipe barrel shall not be reduced by more than 5 percent of its base diameter when measured after backfilling and compacting but prior to final paving and prior to leakage testing. If this amount of allowable pipe deflection is exceeded, the Contractor shall uncover the pipe and shall improve the quality of the pipe zone backfill material and/or compaction to the extent that the allowable pipe deflection is not exceeded. Excessive deflection shall be checked for by pulling a mandrel through the pipe, or by other methods acceptable to the Engineer.

- B. Field testing of gravity sewer pipe shall conform to the requirements of Section 33 05 05.32 - Gravity Pipeline Testing.

END OF SECTION

SECTION 33 05 62 – PRECAST CONCRETE MANHOLES AND VAULTS

PART 1 -- GENERAL

1.01 SUMMARY

- A. The Contractor shall provide precast concrete manholes and vaults, complete and in place, in accordance with the Contract Documents.

1.02 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

A. Reference Specifications

01 33 00	Contractor Submittals
05 50 00	Metal Fabrications

B. Reference Standards

American Society for Testing and Materials (ASTM) Standards	
ASTM A48	Gray Iron Castings
ASTM C595	Blended Hydraulic Cement, Type IL
ASTM C443	Joints for Circular Concrete Sewer and Culvert Pipe, Using Rubber Gaskets
ASTM C478/C478M	Standard Specifications for Circular Precast Reinforced Concrete Manhole Sections
ASTM C913	Standard Specification for Precast Concrete Water and Wastewater Structures
ASTM C923	Standard Specification for Resilient Connectors Between Reinforced Concrete Manhole Structures, Pipes, and Laterals

1.03 CONTRACTOR SUBMITTALS

- A. General: Furnish submittals in accordance with Section 01 33 00 – Contractor Submittals.
- B. Shop Drawings
1. Show dimensions, locations, lifting inserts, reinforcement, and joints.
 2. Structural design calculations for vaults, signed by a registered engineer.
- C. Manufacturer's Certification for Vaults: Written certification that the vault complies with the requirements of this Section.
- D. Manufacturer's Test Results: Pull out force for manhole steps.

1.04 QUALITY ASSURANCE

- A. Inspection: After installation, the Contractor shall demonstrate that manholes and vaults have been properly installed, level, with tight joints, at the correct elevations and orientations, and that the backfilling has been carried out in accordance with the Contract Documents.

PART 2 -- PRODUCTS

2.01 MANHOLES

- A. The Contractor shall provide precast manhole sections and conical sections conforming to ASTM C478 and the requirements of this Section. Adjusting rings shall be standard items from the manufacturer of the manhole sections. Minimum wall thickness of rings shall be 4-inches if steel reinforced and 6-inches if not reinforced.
- B. Axial length of sections shall be selected to provide the correct total height with the fewest joints.
- C. Conical sections shall be designed to support cast iron frames and covers under an H-20 loading, unless indicated otherwise.
- D. Where the manhole barrel diameter is greater than 48-inches, a flat slab-transition, either concentric or eccentric, shall be used to transition to 48-inches diameter riser sections. Underside of the transition shall be at least 7-feet above the top of the bench.
- E. Where indicated on the Drawings, manholes supplied for 48-inches and larger pipes shall be of a "T" Base-style fabrication. The pipeline portion of the "Base T" section shall conform to ASTM C-76 and be of the same pipe class as the deepest connected sewer. The riser section shall conform to ASTM C478.
- F. Design Criteria: Manhole walls, transitions, conical sections, and base shall be designed per ASTM C478 for the depths indicated and the following:
 - 1. AASHTO H-20 loading applied to the cover.
 - 2. Unit weight of soil of 120 pcf located above all portions of the manhole.
 - 3. Lateral soil pressure based on saturated soil producing 100 pcf.
 - 4. Internal fluid pressure based on unit weight of 63 pcf with manhole filled from invert to cover with no balancing external soil pressure.
 - 5. Dead load of manhole sections fully supported by the base and transition.
 - 6. Additional reinforcing steel in walls to transfer stresses at openings.
 - 7. The minimum clear distance between the edges of any 2 wall penetrations shall be 12-inches or one-half of the diameter of the smaller penetration, whichever is greater.
- G. Joints shall be sealed with o-ring gaskets conforming to ASTM C443.
- H. Concrete for base and channel formation shall be 4000 psi.

PRECAST CONCRETE MANHOLES AND VAULTS

- I. Except were otherwise indicated on the Drawings, manholes shall have a precast concrete base and a factory installed bench.
- J. Barrel section to sewer pipe connections shall be sealed with resilient connectors complying with ASTM C923. Mechanical devices shall be stainless steel.
- K. Manhole Steps shall be in accordance with Section 05 50 00 – Metal Fabrications.
- L. Manhole Manufacturers,
 - 1. Atlantic Concrete Products, Inc.
 - 2. Hanson Concrete Products, Inc.
 - 3. Hardwall Fabricators, Inc.
 - 4. Teichert Precast
 - 5. or Approved Equal

2.02 FRAMES AND COVERS

- A. Castings: Castings for manhole frames and covers shall be non-rocking and shall conform to the requirements of ASTM A48, Class 30. Unless otherwise indicated, cast iron covers and frames shall be heavy traffic type, 30-inches in diameter, with embossed lettering saying "Water" to meet the requirements of the City or the local utility company. Frame and cover shall be designed for H-20 traffic loading.
- B. Castings Manufacturers,
 - 1. East Jordan Iron Works, Co.
 - 2. Neenah Foundry Co.

2.03 SURFACE APPLIED BITUMINOUS WATERPROOFING MATERIAL

- A. Bituminous waterproofing material shall be Karnak Corporation 920 Fibered Emulsion or approved equal.

2.04 VAULTS

- A. The Contractor shall provide precast vaults designed for the indicated applications and of the sizes indicated.
- B. The minimum structural member thickness for vaults shall be 5-inches. Cement shall be Type V portland cement as specified in ASTM C150. The minimum 28-day concrete compressive strength shall be 4,000 psi (27.5 MPa). All reinforcing steel shall be embedded in the concrete with a minimum clear cover as recommended by ACI 318.
- C. Design Loading: Vaults in areas subject to vehicular traffic shall be designed for H-20 traffic loading. Vaults in other areas shall be designed for a vertical live load of 300 psf. Lateral loads on vaults in all areas shall be calculated from:

$$L = 90 \times h \text{ (27.44} \times h\text{)}, \text{ plus surcharge of 240 psf in areas of vehicular traffic}$$

PRECAST CONCRETE MANHOLES AND VAULTS

Where: L= loading in psf (kPa)

h = depth of fill in feet (meter)

- D. Where joints are designed in pre-cast concrete vaults, such joints shall be interlocking to secure proper alignment between members and prevent migration of soil through the joint. Structural sections at joints shall be sized sufficiently to reinforce the section against localized distress during transportation and handling and against excess contact bearing pressures through the joint.
- E. Where openings for access to the vault are required, the full clear space opening indicated shall be provided, without obstructions from brackets or supports. For large openings where brackets or supports are designed to protrude into the opening for support of required covers, such brackets or supports shall be designed to be easily removed and replaced with a minimum of effort and without cutting or welding.
- F. Covers for access openings shall be provided. Frames for covers shall be fabricated from steel, galvanized after fabrication, and shall be integrally cast into the vault concrete sections. All covers shall be tight fitting to prevent the entrance of dirt and debris. Where edge seams are permitted, no gaps greater than 1/16-inch between edges will be accepted. All covers, except round, heavy weight, cast iron manhole covers, shall have securing mechanisms to hold the covers firmly in place against the effects of repetitious live loads such as pedestrian or vehicle traffic.
- G. Where penetration of the pre-cast concrete vault is required for piping, conduit, or ducts, such penetrations shall be accommodated through pre-cast openings or thin-wall knock-out sections. All openings for penetrations shall be smooth and free of surface irregularities and without exposed steel reinforcing. Vaults need not be designed to resist thrust from piping passing through the vault.

PART 3 -- EXECUTION

3.01 GENERAL

- A. Pre-cast concrete sections shall be transported and handled with care in accordance with the manufacturer's written recommendations. Where lifting devices are provided in pre-cast sections, such lifting devices shall be used as intended. Where no lifting devices are provided, the Contractor shall follow the manufacturer's recommendations for lifting procedures to provide proper support during lifting.
- B. Buried pre-cast concrete vaults shall be assembled and placed in excavations on properly compacted soil foundations or bedding as indicated. Pre-cast concrete vaults shall be set to grade and oriented to provide the required dimensions and clearances from pipes and other structures.
- C. Prior to backfilling, all cracks and voids in pre-cast concrete vaults shall be filled with non-shrink grout or polyurethane sealant, or both. Around pipe and conduit penetrations, openings shall be sealed with polyurethane sealant or link seal. With the authorization of the Engineer, grout or a closed-cell flexible insulation may be used as filler material prior to placing a final bed of polyurethane sealant.
- D. Provide manhole steps/rungs as required by Owner. Manhole Steps shall be in accordance with Section 05 50 00 – Metal Fabrications.

- E. Steps shall be driven into tapered holes formed in the concrete by inserts from the step manufacturer or 1-inch holes drilled 3-3/4 inches deep into the manhole wall in the field. No more than 6-1/8 inches of plastic arm, measured on the inside of the step, shall be exposed outside the concrete.

3.02 SURFACE APPLIED BITUMINOUS WATERPROOFING MATERIAL

The Contractor shall paint the exterior part of the vertical concrete walls, with bituminous waterproofing material. Extreme care shall be taken to keep all interior exposed concrete surfaces free from bituminous waterproofing and/or splatters. Apply only to clean, firm, and dry surfaces, and in accordance with manufacturer's instructions.

END OF SECTION

SECTION 33 11 00 – COPPER PIPE AND TUBING

PART 1 -- GENERAL

1.01 THE SUMMARY

- A. The Contractor shall provide copper tube and appurtenances complete in place, in accordance with the Contract Documents
- B. Pipes, pipe fittings, and plumbing fixtures shall have no more than 0.25 percent lead in the wetted surface material.

1.02 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

A. Reference Standards

American Society of Mechanical Engineers (ASME)	
ASME B16.18	Cast Copper Alloy Solder Joint Pressure Fittings
ASME B16.22	Wrought Copper and Copper Alloy Solder - Joint Pressure Fittings
ASME B16.24	Cast Copper Alloy Pipe Flanges and Flanged Fittings
ASME B16.26	Cast Copper Alloy Fittings for Flared Copper Tubes
ASTM International (ASTM)	
ASTM B62	Composition Bronze or Ounce Metal Castings
ASTM B88	Seamless Copper Water Tube

1.03 CONTRACTOR SUBMITTALS

- A. Shop Drawings: The Contractor shall submit Shop Drawings in accordance with Section 01 33 00 – Submittal Procedures. Include manufacturer's data on materials, covering, coating, insulation, piping, fittings, anchors, expansion joints, supports, seals, and closures.
- B. Manufacturer's Data: Data submitted with the Shop Drawings shall certify that all materials meet the standards and k-factors, and that the proposed sealing method will obtain a watertight system.

1.04 QUALITY ASSURANCE

- A. Inspection and Testing: After completion of the pipe installation, and prior to covering of field joints, the entire piping system shall be subject to a hydrostatic test of 150 psig or 1-1/2 times the working pressure, whichever is greater, for a period of 4 hours. Any leaks or loss of pressure shall be traced and repaired at that time, and the system shall be re-tested until found tight.
- B. Acceptance Criteria: Acceptance of the piping system shall be dependent on the satisfactory completion of the above-mentioned test.

PART 2 -- PRODUCTS

2.01 PIPE MATERIAL

- A. Copper water tube shall conform to the requirements of ASTM B88 - Seamless Copper Water Tube and shall be soft temper tube in rolls for buried locations, or hard drawn lengths for other applications. Unless otherwise indicated, copper water tube shall be of Type K wall thickness.

2.02 JOINTS

- A. Copper water tube shall have soldered joints, flared ends and fittings, or compression type joints. Soldered joints shall be made with 95 - 5 percent tin-antimony solder or with silver solder. Buried piping shall have flared or compression type joints. No soft-soldered joints will be allowed on buried piping. No solders containing more than 0.2 percent lead shall be used.

2.03 FITTINGS

- A. Soldered Fittings: Soldered fittings shall conform to ASME B16.18 - Cast Copper Alloy Solder Joint Pressure Fittings, or to ASME B16.22 - Wrought Copper and Copper Alloy Solder - Joint Pressure Fittings. The soldering flux shall be the manufacturer's approved type for the fitting and solder used.
- B. Flared Fittings: Flared fittings shall conform to ASME B16.26 - Cast Copper Alloy Fittings for Flared Copper Tubes.
- C. Compression Fittings: Compression type fittings shall be brass fittings as manufactured by Crawford Company - SWAGELOK, Parker-Hannifin - CPI, or equal.
- D. Flanged Fittings: Cast copper alloy flanges and flanged fittings shall be in accordance with ASME B16.24 - Cast Copper Alloy Pipe Flanges and Flanged Fittings, and ASTM B62 - Composition Bronze or Ounce Metal Castings, with Class 150. ratings, or as indicated.

PART 3 -- EXECUTION

3.01 GENERAL

- A. Installation, inspection and field testing of the pipes shall in accordance with the requirements of Section 40 05 01 - Piping General.

END OF SECTION

SECTION 33 40 00 – STORMWATER UTILITIES

PART 1 -- GENERAL

1.01 SUMMARY

- A. The Contractor shall provide storm drain piping, complete and in place, in accordance with the Contract Documents.

1.02 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

A. Reference Specifications

01 33 00	Submittal Procedures
03 30 00	Cast-in-Place Concrete
31 20 00	Earthwork Methods
31 23 16	Trench and Minor Structure Excavation

B. Reference Standards

American Society for Testing and Materials (ASTM) Standards	
ASTM C76	Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe
ASTM C478	Circular Precast Reinforced Concrete Manhole Sections
ASTM C443	Joints for Concrete Pipe and Manholes, Using Rubber Gaskets
ASTM C506	Reinforced Arch Culvert, Storm Drain, and Sewer Pipe
ASTM C507	Reinforced Concrete Elliptical Culvert, Storm Drain, and Sewer Pipe
ASTM C655	Reinforced Concrete D-Load Culvert, Storm Drain, and Sewer Pipe
ASTM C923	Resilient Connectors Between Reinforced Concrete Manhole Structures, Pipes, and Laterals
ASTM C969	Infiltration and Exfiltration Acceptance Testing of Installed Precast Concrete Pipe Sewer Lines
ASTM C990	Joints for Concrete Pipe, Manholes, and Precast Box Sections, Using Preformed Flexible Joint Sealants
ASTM C1103	Joint Acceptance Testing of Installed Precast Concrete Pipe Sewer Lines
ASTM C1433	Precast Reinforced Concrete Monolithic Box Sections for Culverts, Storm Drains, and Sewers
ASTM D1784	Rigid Poly(Vinyl Chloride) (PVC) Compounds and Chlorinated Poly(Vinyl Chloride) (CPVC) Compounds
ASTM D2321	Underground Installation of Thermoplastic Pipe for Sewers and Other Gravity-Flow Applications
ASTM D2680	ABS and PVC Composite Sewer Piping
ASTM D2729	Poly (Vinyl Chloride) (PVC) Sewer Pipe and Fittings
ASTM D3034	Type PSM Poly (Vinyl Chloride) (PVC) Sewer Pipe and Fittings
ASTM D3212	Joints for Drain and Sewer Plastic Pipes Using Flexible Elastomeric Seals

ASTM F477	Elastomeric Seals (Gaskets) for Joining Plastic Pipe
ASTM F679	Poly(Vinyl Chloride) (PVC) Large-Diameter Plastic Gravity Sewer Pipe and Fittings
ASTM F714	Polyethylene (PE) Plastic Pipe (DR-PR) Based on Outside Diameter
ASTM F794	Poly(Vinyl Chloride) (PVC) Profile Gravity Sewer Pipe and Fittings Based on Controlled Inside Diameter
ASTM F894	Polyethylene (PE) Large Diameter Profile Wall Sewer and Drain Pipe
ASTM F949	Poly (Vinyl Chloride) (PVC) Corrugated Sewer Pipe with a Smooth Interior and Fittings
ASTM F1417	Installation Acceptance of Plastic Non-pressure Sewer Lines Using Low-Pressure Air
ASTM F2736	Polypropylene (PP) Corrugated Single Wall Pipe And Double Wall Pipe, 6 to 30-in
ASTM F2764	Polypropylene (PP) Corrugated Double and Triple Wall Pipe and Fittings for Non-Pressure Sanitary Sewer Applications, 12 to 60-in
ASTM F2881	Polypropylene (PP) Dual Wall Pipe and Fittings for Non-Pressure Storm Sewer Applications, 12 to 60-in
American Water Works Association (AWWA) Standard	
C104	Cement-Mortar Lining for Ductile-Iron Pipe and Fittings
C111	Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings
C151	Standard for Ductile Iron Pipe, Centrifugally Cast
American Association of State Highway and Transportation Officials (AASHTO) Standard	
M36	Corrugated Steel Pipe, Metallic Coated, for Sewers and Drains
M196	Corrugated Aluminum Pipe for Sewers and Drains
M252	Corrugated Polyethylene Drainage Pipe
M294	Corrugated Polyethylene Pipe 12 to 60-in Diameter

1.03 SUBMITTALS

- A. Shop Drawings and catalog data submittals shall be made in accordance with Section 01 33 00 – Submittal Procedures.
- B. Provide manufacturer's product information, shop drawings, and O&M information for storm drainage materials including:
 1. Pipe
 2. Fittings
 3. Pre-Cast and Cast-in-Place Structures
 4. Outfalls
 5. Castings
 6. Inlets

- C. A manufacturer's or fabricator's Certificate of Compliance shall be furnished stating that samples representing each lot have been tested and inspected in accordance with the Contract Documents and have been found to meet the requirements for the material described.

1.04 CLEARING

- A. Clearing for installation of pipe and drainage structures shall be confined within the working limits of the trenches. Trees, utility poles, survey monuments, and underground and overhead utilities shall be suitably protected and preserved.

1.05 EXISTING UTILITIES

- A. Contractor shall furnish temporary support, adequate protection, and maintenance of underground and surface utility structures, drains, sewers, cables, etc., and other obstructions encountered in the progress of the Work.
- B. When the grade of alignment of the pipe is obstructed by existing utility structures, such as conduits, ducts, pipes, branch connections to water or sewer mains, and other obstructions, the obstructions shall be permanently supported, relocated, removed or reconstructed by the Contractor in cooperation with the owners of such structures. No deviation shall be made from the required line or grade except as accepted in writing by the Engineer.
- C. It shall be the responsibility of the Contractor to notify the owners of existing utilities in the area of construction a minimum of 48 hours prior to any excavation adjacent of such utilities, so that field locations of said utilities may be established.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Delivery and Storage

- 1. Materials delivered to site shall be inspected for damage, unloaded, and stored with a minimum of handling. Materials shall not be stored directly on the ground. The inside of pipes and fittings shall be kept free of dirt and debris. Before, during, and after installation, pipe and fittings shall be protected from any environment that would result in damage or deterioration to the material. Solvents, solvent compounds, lubricants, elastomeric gaskets, and any similar materials required to install pipe shall be stored in accordance with the manufacturer's recommendations and shall be discarded if the storage period exceeds the recommended shelf life. Solvents in use shall be discarded when the recommended pot life is exceeded.

B. Handling

- 1. Materials shall be handled in a manner that ensures delivery to the trench in sound, undamaged condition. Pipe shall not be rolled or dragged over gravel or rock, and during placement, shall be prevented from striking rock or other hard objects. Special care shall be taken in handling and placing coated pipe to avoid damaging any coating.

PART 2 -- PRODUCTS

2.01 PIPE

A. CORRUGATED METAL PIPE (CMP)

1. Corrugated metal pipe shall include round pipe, pipe arch, and underdrain pipe, both corrugated steel and corrugated aluminum, coated and uncoated, with or without a paved invert, and including fittings, couplings, and related accessories.
2. Corrugated steel pipe, pipe arch, and underdrain and coupling bands and fittings for each type, shall conform to the requirements of AASHTO M-36.
3. Corrugated aluminum pipe, pipe arch, underdrain and coupling bands and fittings for each type, shall conform to the requirements of AASHTO M-196.

PART 3 -- EXECUTION

3.01 EXCAVATIONS

- A. Trench walls shall be compliant with local Occupational Health and Safety regulations and as vertical as practical given regulatory constraints. and , if required, trench walls shall be properly sheeted and braced. Where, in the opinion of the Engineer, damage could result from withdrawing sheeting, the sheeting shall be left in place. Not more than 100 ft of trench shall be opened at any one time or in advance of pipe laying unless permitted by the Engineer.
1. Except in rock, water-bearing earth, or where a granular or concrete base is to be used, mechanical excavation of trenches shall be stopped above the final grade elevation so that the pipe may be laid on a firm, undisturbed native earth bed. If over-digging occurs, loosened earth shall be removed, and the trench bottom brought back to grade with granular material.
 2. Excavations and trenches in rock shall be carried to a depth of not less than 8 in below the pipe bottom. This space shall be filled with granular material or washed rock.
 3. Width of trenches shall be such as to provide adequate space for placing and jointing pipe properly, but in every case the trench shall be kept to a minimum width.
 4. Unstable soil shall be removed and replaced with gravel, crushed rock, or rock and sand suitably compacted.

3.02 PREPARATION OF TRENCH BOTTOM

- A. Water shall not be allowed in the trenches while the trench bottom is being prepared or while pipe is being installed, unless accepted by the Engineer.
- B. A continuous trough shall be shaped a minimum of 8 in below the bottom of the pipe to receive the bottom quadrant of the pipe barrel. Bell holes shall be excavated so that after placement, only the barrel of the pipe receives bearing pressure from the trench bottom.

3.03 INSTALLATION OF DRAINAGE PIPE

- A. Pipe shall be protected during handling against impact shocks and free falls. Pipe shall be kept clean, and no pipe shall be used that does not conform to the Specifications.
- B. The laying of the pipe shall be commenced at the lowest point with spigot ends pointing in the direction of flow. Pipe shall be laid with ends abutting and true to line and grade and in accordance with manufacturer's requirements.
- C. Pipe shall be laid accurately to the line and grade required. Preparatory to making pipe joints, surfaces of the portions of the pipe to be jointed or of the factory-made jointing material shall be clean and dry. Lubricant, primers, adhesive, etc., shall be used as recommended by the pipe or joint manufacturer's specifications. The jointing materials or factory-fabricated joints shall then be placed, fitted, joined, and adjusted in such a manner as to obtain a watertight line. As soon as possible after the joint is made, sufficient backfill material shall be placed along each side of the pipe to prevent movement of pipe.
- D. The exposed ends of pipe shall be suitably plugged to prevent earth, water, or other substances from entering the pipe when construction is not in progress.

3.04 BACKFILLING TRENCHES

- A. Pipe trench backfill shall be in accordance with the requirements of Section 31 20 00 – Earthwork Methods and 31 23 16 – Trench and Minor Structure Excavation.
- B. No trenches or excavations shall be backfilled until the trench and installation has been inspected and written approval given by the Engineer. Under no circumstances shall water be permitted to rise in un-backfilled trenches after pipe has been placed. Trenches shall be backfilled with compliant material, free of large clods, stones, or rocks, and carefully deposited in layers not to exceed 6-in until enough fill has been placed to provide a cover of not less than one-foot above the pipe. Each layer shall be placed, then carefully and uniformly tamped as to eliminate the possibility of pipe displacement. The remainder of backfill materials shall then be placed, moistened, and compacted in 6-in layers.
- C. Whenever the trenches have been improperly filled or if settlement occurs, they shall be refilled, compacted, smoothed off, and made to conform to grade. Unless otherwise directed, backfill in trenches in or through roadways shall be made as indicated, except that the entire fill above one-foot over the pipe shall be deposited in layers not to exceed 8-in in thickness, moistened, and compacted to density equal to or greater than that of adjacent material so that pavement can be placed immediately.

3.05 CONCRETE ENCASEMENT OF DRAINAGE PIPE

- A. Trenches in which encasement for pipe is to be placed may be excavated completely with mechanical equipment. Prior to formation of the encasement, temporary supports consisting of timber wedges or masonry shall be used to support the pipe in place. Temporary supports shall have minimum dimensions and shall support the pipe at no more than 2 places, one at the bottom of the barrel of the pipe adjacent to the shoulder of the socket and the other near the spigot end.

3.06 INSPECTION

- A. The Engineer shall inspect the storm drainage system prior to accepting the Work. Repairs or misalignment shall be corrected. Pipe shall be thoroughly cleaned before being placed into use and shall be kept clean until final acceptance.

3.07 RESTORATION OF SURFACES AND/OR STRUCTURES

- A. The Contractor shall restore and/or replace paving, curbing, sidewalks, fences, and survey points, or any other disturbed surfaces or structures to a condition equal to that before the Work was begun and to the satisfaction of the Engineer. The Contractor shall comply with requirements of governing agencies including town, city, and state for restoration of surfaces and/or structures.

END OF SECTION

SECTION 33 92 20 – DUCTILE IRON PIPING

PART 1 -- GENERAL

1.01 THE SUMMARY

- A. The CONTRACTOR shall provide ductile iron pipe and appurtenant WORK, complete and in place, in accordance with the Contract Documents.

1.02 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

AWWA C104	Cement-Mortar Lining for Ductile-Iron Pipe and Fittings for Water
AWWA C105	Polyethylene Encasement for Ductile-Iron Pipe Systems
AWWA C110	Ductile-Iron and Gray-Iron Fittings, 3 in through 48 in for Water
AWWA C111	Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings
AWWA C115	Flanged Ductile-Iron Pipe with Ductile-Iron or Gray-Iron Threaded Flanges
AWWA C116	Protective Fusion-Bonded Epoxy Coatings for the Interior and Exterior Surfaces of Ductile-Iron and Gray-Iron Fittings for Water Supply Service.
AWWA C150	Thickness Design of Ductile-Iron Pipe
AWWA C151	Ductile-Iron Pipe, Centrifugally Cast for Water
AWWA C153	Ductile-Iron Compact Fittings. for Water Service
AWWA C600	Installation of Ductile Iron Water Mains and Their Appurtenances
AWWA C606	Grooved and Shouldered Joints
ASTM C 150	Portland Cement

1.03 SUBMITTAL PROCEDURES

- A. Furnish Submittals in accordance with Section 01 33 00 – Submittal Procedures, and the following supplemental requirements:
- B. Shop Drawings
 - 1. Certified dimensional drawings of valves, fittings, and appurtenances.
 - 2. For pipe 24-inches diameter and larger, line layout and marking diagrams which indicate the specific number of each fitting and the location and the direction of each fitting in the completed line. In addition, the line layouts shall include: the pipe station and invert elevation at changes in grade or horizontal alignment; elements of curves and bends, both in horizontal and vertical alignment; and the limits of each reach of restrained joints, or of concrete encasement.

DUCTILE IRON PIPING

- C. Certifications: Certified affidavit of compliance for pipe and other products or materials furnished under this Section and as specified in the referenced standards and the following supplemental requirements:
 - 1. Physical and chemical properties.
 - 2. Hydrostatic test reports.
- D. The CONTRACTOR shall be responsible for performing and paying for sampling and testing as necessary for the certifications.

1.04 QUALITY ASSURANCE

- A. Tests: Except as modified herein, materials used in the manufacture of the pipe shall be tested in accordance with the requirements of the referenced standards as applicable.
- B. The CONTRACTOR shall perform said material tests as part of the WORK. The ENGINEER shall have the right to witness testing conducted by the CONTRACTOR; provided, that the CONTRACTOR's schedule is not delayed for the convenience of the ENGINEER.
- C. In addition to those tests specifically required, the ENGINEER may request additional samples of any material including lining and coating samples for testing by the OWNER. The additional samples shall be furnished as a part of the WORK.
- D. Inspection: Pipe shall be subject to inspection at the place of manufacture in accordance with the provisions of the referenced standards, as supplemented by the requirements herein. The CONTRACTOR shall notify the ENGINEER in writing of the manufacturing starting date not less than 14 Days prior to the start of any phase of the pipe manufacture.
- E. During the manufacture of the pipe, the ENGINEER shall be given access to areas where manufacturing is in process and shall be permitted to make inspections necessary to confirm compliance with the Specifications.

PART 2 -- PRODUCTS

2.01 PIPE GENERAL

- A. Mortar-lined and polyethylene-wrapped ductile iron pipe shall conform to AWWA C151, C104, and C105, subject to the supplemental requirements in this Section. The pipe shall be of the diameter and class indicated, shall be provided complete with rubber gaskets, specials, and fittings as required under the Contract Documents.
- B. Markings: The CONTRACTOR shall legibly mark specials 24-inches diameter and larger in accordance with the laying schedule and marking diagram. Each fitting shall be marked at each end with top field centerline.
- C. Handling and Storage: The pipe shall be handled as a minimum at the 1/3 points by use of wide slings, padded cradles, or other devices designed and constructed to prevent damage to the pipe coating/exterior. The use of chains, hooks, or other equipment that might injure the pipe coating/exterior will not be permitted. Stockpiled pipe shall be supported on padded skids, sand or earth berms free of rock exceeding 3-inches diameter,

sand bags, or suitable means so that the coating will not be damaged. The pipe shall not be rolled and shall be secured to prevent accidental rolling

D. Bonded dielectric-coated pipe shall have the following additional requirements:

1. It shall be the responsibility of the CONTRACTOR to prevent damage of the coating that might be caused by handling and/or storage of the completed pipe at low temperature.

E. Laying Lengths: Nominal pipe laying lengths shall be 20-feet.

F. Finish: The pipe shall have smooth dense interior surfaces and shall be free from fractures, excessive interior surface crazing, and roughness.

G. Bonding and Electrical Conductivity: Pipe joints shall be prepared for bonding for electrical conductivity in accordance with the details indicated. The CONTRACTOR shall furnish materials required for joint bonding and electrolysis test station installations.

H. Closures and Correction Pieces: Closures and correction pieces shall be provided as required so that closures may be made due to different headings in the pipe laying operation and so that correction may be made to adjust the pipe laying to conform to pipe stationing on the Drawings. The locations of correction pieces and closure assemblies are indicated. Any change in location or number of said items shall only be as accepted by the ENGINEER.

2.02 SPECIALS AND FITTINGS

A. Fittings for ductile iron pipe shall conform to the requirements of AWWA C153 or AWWA C110 and shall have a minimum pressure rating of 250 psi. Ductile iron fittings larger than 48-inches shall conform to AWWA C153.

2.03 DESIGN OF PIPE

A. The pipe shall be designed, manufactured, tested, inspected, and marked according to AWWA C150 and C151 except where modified by this Section.

B. Pipe Dimensions: The pipe shall be of the diameter and class indicated.

C. Fitting Dimensions: The fittings shall be of the diameter and class indicated.

D. Joint Design: Ductile iron pipe and fittings for buried pressure service shall be furnished with restrained joints, unless otherwise indicated. Ductile iron pipe and fittings for buried gravity service shall be furnished with mechanical joints or push-on joints as required, unless otherwise indicated. Above ground ductile iron pipe and fittings joints shall be as indicated. Flanged joints or grooved and shouldered joints shall be furnished where required.

1. Mechanical and push-on joints shall conform to AWWA C111.

2. Flanged joints shall conform to AWWA C115. Where threaded flanges are provided, the pipe wall thickness under the cut threads shall not be less than the calculated net thickness required for the pressure class of the pipe.

3. Restrained joints shall be **Flex-Ring** restrained joint by **American Ductile Iron Pipe, TR FLEX** restrained joint by **U.S. Pipe**, or equal.
 4. Joint restraining devices that impart point loads and/or wedging action on the pipe wall as a means of joint restraint shall not be allowed unless there are no other options for joint restraint available. Under such circumstances, the CONTRACTOR may propose such devices provided the following conditions are met and the request is made as a substitution:
 - a. A formal request for substitution is submitted stating the locations where the devices are intended to be used and a statement from the device manufacturer and the pipe manufacturer that the proposed device is appropriate for the intended installation and is rated at least for the class of the pipe being supplied.
 - b. A statement from the pipe manufacturer is provided accepting the use of the retaining devices and indicating that the use of such devices will in no way affect the warranty of the pipe and/or the performance of the pipe.
 - c. The manufacturer of the device and the pipe manufacturer jointly provide instruction on the proper installation of the device to the personnel installing the units and provide certification to the OWNER that the installers are adequately trained in the installation of the units and that warranties are in full affect for the project.
 - d. The devices shall be **MegaLug Model 1100** as manufactured by **EBAA Iron** or equal.
 5. Grooved and Shouldered Joints shall meet the requirements of mechanical-type couplings in accordance with Section 40 05 01 – Piping, General and conform to AWWA C606.
- E. For bell-and-spigot ends with rubber gaskets, the clearance between the bells and spigots shall be such that when combined with the gasket groove configuration and the gasket itself, will provide watertight joints under all operating conditions when properly installed. The CONTRACTOR shall require the pipe manufacturer to submit details complete with significant dimensions and tolerances and also to submit performance data indicating that the proposed joint has performed satisfactorily under similar conditions. In the absence of a history of field performance, the results of a test program shall be submitted.

2.04 CEMENT-MORTAR LINING

- A. Cement-Mortar Lining for Shop Application: Except as otherwise provided herein, interior surfaces of ductile iron pipe, fittings, and specials shall be cleaned and lined in the shop with cement-mortar lining applied centrifugally in conformity with AWWA C104. During the lining operation and thereafter, the pipe shall be maintained in a round condition by suitable bracing or strutting. The lining machines shall be of a type that has been used successfully for similar work. Every precaution shall be taken to prevent damage to the lining. If lining is damaged or found defective at the Site, the damaged or unsatisfactory portions shall be replaced with lining conforming to these Specifications.
1. Cement: Cement for mortar lining shall conform to the requirements of AWWA C104; provided, that cement for mortar lining shall be Type II or V. Cement shall not

originate from kilns that burn metal-rich hazardous waste fuel, nor shall a fly ash or pozzolan be used as a cement replacement.

- B. The minimum lining thickness shall be as follows:

Nominal Pipe Diameter, inches	Minimum Lining Thickness, inches
3 - 12	1/16
14 - 24	3/32
30 - 64	1/8

- C. Protection of Pipe Lining/Interior: Shop-applied cement mortar lining shall be given a seal coat of asphaltic material in conformance with AWWA C104.

2.05 EXTERIOR PROTECTION OF PIPE

- A. Exterior Coating of Exposed Piping: The exterior surfaces of pipe which will be exposed to the atmosphere inside structures or above ground shall be thoroughly cleaned and then given a shop coat of rust-inhibitive primer conforming to the requirements of Section 09 96 00 - High Performance Coatings.
- B. Exterior Coating of Buried Piping: The exterior coating shall be an asphaltic coating approximately 1-mil thick.
- C. Polyethylene Sleeve: Sleeves shall be V-BIO Enhanced Polyethylene and conform to the requirements of AWWA C105/A21.5.

PART 3 -- EXECUTION

3.01 INSTALLATION OF PIPE

- A. The CONTRACTOR shall inspect each pipe and fitting prior to installation to insure that there are no damaged portions of the pipe. Pipe damaged prior to Substantial Completion shall be repaired or replaced by the CONTRACTOR.
- B. Before placement of pipe in the trench, each pipe or fitting shall be thoroughly cleaned of any foreign substance which may have collected thereon and shall be kept clean at all times thereafter. For this purpose, the openings of pipes and fittings in the trench shall be closed during any interruption to the WORK.
- C. Pipe Laying: The pipe shall be installed in accordance with AWWA C600.
- D. Pipe shall be laid directly on the bedding material. No blocking will be permitted, and the bedding shall be such that it forms a continuous, solid bearing for the full length of the pipe. Excavations shall be made as needed to facilitate removal of handling devices after the pipe is laid. Bell holes shall be formed at the ends of the pipe to prevent point loading at the bells or couplings. Excavation shall be made as needed outside the normal trench section at field joints to permit adequate access to the joints for field connection operations and for application of coating on field joints.

- E. Each section of pipe 24-inches diameter and larger shall be laid in the order and position shown on the laying schedule. Each section shall be laid to the line and grade, within approximately one-inch plus or minus.
- F. Where necessary to raise or lower the pipe due to unforeseen obstructions or other causes, the ENGINEER may change the alignment and/or the grades. Such change shall be made by the deflection of joints, by the use of bevel adapters, or by the use of additional fittings. However, in no case shall the deflection in the joint exceed 75 percent of the maximum deflection recommended by the pipe manufacturer. No joint shall be misfit any amount that will be detrimental to the strength and water tightness of the finished joint.
- G. Except for short runs that may be permitted by the ENGINEER, pipes shall be laid uphill on grades exceeding 10 percent. Pipe that is laid on a downhill grade shall be blocked and held in place until sufficient support is furnished by the following pipe to prevent movement. Bends shall be properly installed as indicated.
- H. Cold Weather Protection: No pipe shall be installed upon a foundation into which frost has penetrated or at any time that there is a danger of the formation of ice or penetration of frost at the bottom of the excavation before backfilling occurs.
- I. Pipe and Specials Protection: The openings of pipe and specials shall be protected with suitable bulkheads to prevent unauthorized access by persons, animals, water, or any undesirable substance. At all times, means shall be provided to prevent the pipe from floating.
- J. Pipe Cleanup: As pipe laying progresses, the CONTRACTOR shall keep the pipe interior free of debris. The CONTRACTOR shall completely clean the interior of the pipe of sand, dirt, mortar splatter, and any other debris following completion of pipe laying and shall perform any necessary interior repairs prior to testing and disinfecting the completed pipeline.

3.02 RUBBER GASKETED JOINTS

- A. Rubber Gasketed Joints: Immediately before jointing pipe, the bell end of the pipe shall be thoroughly cleaned, and a clean rubber gasket shall be placed in the bell groove. The spigot end of the pipe and the inside surface of the gasket shall be carefully cleaned and lubricated. The lubricant shall be suitable for lubricating the parts of the joint for assembly and be a compound listed as in compliance with NSF Standard 61. The lubricant shall be nontoxic, shall not support the growth of bacteria, and shall have no deleterious effects on the gasket material. The lubricant shall not impart taste or odor to water in the pipe. The spigot end of the pipe section shall then be inserted into the bell of the previously laid joint and telescoped into its proper position. Tilting of the pipe to insert the spigot into the bell will not be permitted.

3.03 POLYETHYLENE SLEEVE UNBONDED PROTECTION

- A. Buried ductile iron pipe shall be V-BIO Enhanced Polyethylene encased in accordance with the requirements of AWWA C105/A21.5, Method C.
- B. Concrete-encased ductile iron pipe and ductile iron pipe directly in contact with concrete thrust blocks shall be V-BIO Enhanced Polyethylene encased in accordance with the requirements of AWWA C105.

3.04 INSTALLATION OF PIPE APPURTENANCES

- A. Protection of Appurtenances: Where the joining pipe is dielectric-coated, buried appurtenances shall be coated in kind. Where pipe is encased in polyethylene sleeves, buried appurtenances shall be encased in polyethylene.
- B. Installation of Valves: Valves shall be handled in a manner to prevent any injury or damage to any part of the valve. Joints shall be thoroughly cleaned and prepared prior to installation. The CONTRACTOR shall adjust stem packing and operate each valve prior to installation to insure proper operation.
- C. Valves shall be installed so that the valve stems are plumb and in the location indicated.

3.05 CORROSION CONTROL

- A. Joint Bonding/Electrolysis Test Stations: Except where otherwise indicated, joints shall be bonded. The pipe shall be cleaned to bare bright metal at the point where the bond is installed. In addition, electrolysis test stations shall be installed where indicated.
- B. Cathodic Protection: Corrosion mitigation and testing materials, such as an impressed current cathodic protection system, magnesium anodes, reference electrodes, and test lead wires shall be provided where indicated.

END OF SECTION

SECTION 40 05 01 – PIPING GENERAL

PART 1 -- GENERAL

1.01 SUMMARY

- A. The Contractor shall provide piping systems indicated, complete and operable, in accordance with the Contract Documents.
- B. The provisions of this Section shall apply to piping in Divisions 33 and 40, and on the Drawings.
- C. The Drawings define the general layout, configuration, routing, method of support, pipe size, and pipe type. The Drawings are not pipe construction or fabrication drawings. The Contractor shall prepare pipe spooling and fabrication drawings and shall submit them to the Engineer for review.
- D. Where pipe layout details are not indicated on the Drawings, it is the Contractor's responsibility to develop the details necessary to design and construct piping systems to accommodate the specific equipment provided, and to provide spacers, adapters, and connectors for a complete and functional system.

1.02 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

A. Definitions

- 1. Pipe, piping, pipe work, pipe system, piping system, or similar words, singular or plural shall mean and include, any type of pipes, tubes, fittings, valves, piping specialties, appurtenances, supports, restraints, anchors, coatings and linings and items related to piping.
- 2. Submerged piping, underwater piping, or similar words shall include any piping located two feet above water surface in basins or tanks.
- 3. Potable water or similar words shall mean and include any type of potable water or process water that be deemed potable after treatment processes.
- 4. Corrosive service shall mean and include in locations listed below:
 - a. Buried locations.
 - b. Submerged locations or submerged piping.
 - c. Inside buried vaults, manholes, and structures that do not drain through a gravity sewer or to a sump with a pump.
 - d. Chemical handling areas.
 - e. Inside trenches, containment walls, and curbed areas.
 - f. Locations indicated or designated in the contract documents.

B. Reference Specifications

01 33 00	Submittals Procedures
01 33 17	Structural Design, Support and Anchorage
09 96 00	High-Performance Coatings
33 05 05.50	Pressure Pipe Testing and Disinfection
40 05 07	Hangers and Supports for Process Piping

C. Reference Standards

American Society of Mechanical Engineers (ASME)	
ASME B1.1	Unified Inch Screw Threads (UN and UNR Thread Form)
ASME B1.20.1	Pipe Threads, General Purpose
ASME B16.5	Pipe Flanges and Flanged Fittings
ASME B31	Boiler and Pressure Vessel Code, Section 9
ASME B31.1	Power Piping
ASTM International (ASTM)	
ASTM A193	Standard Specification for Alloy-Steel and Stainless-Steel Bolting Materials for High-Temperature Service and Other Special Purpose Applications
ASTM A194	Standard Specification for Carbon Steel, Alloy Steel, and Stainless-Steel Nuts for Bolts for High-Pressure or High-Temperature Service, or Both
ASTM A307	Standard Specification for Carbon Steel Bolts, Studs, and Threaded Rod 60 000 PSI Tensile Strength
ASTM A563	Standard Specification for Carbon and Alloy Steel Nuts
ASTM D792	Test Method for Specific Gravity (Relative Density) and Density of Plastics by Displacement
ASTM D2564	Standard Specification for Solvent Cements for Poly (Vinyl Chloride) (PVC)
ASTM F436	Hardened Steel Washers
ASTM F467	Standard Specification for Nonferrous Nuts for General Use
ASTM F468	Standard Specification for Nonferrous Bolts, Hex Cap Screws, and Studs for General Use
ASTM F493	Standard Specification for Solvent Cements for Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe and Fittings
American Welding Society (AWS)	
AWS D1.1	Structural Welding Code
American Water Works Association (AWWA)	
AWWA C115	Flanged Ductile-Iron Pipe with Ductile-Iron or Gray-Iron Threaded Flanges

AWWA C207	Standard for Steel Pipe Flanges for Waterworks Service, Sizes 4 in. through 144 in. (100 mm through 3600 mm)
AWWA C606	Grooved and Shouldered Joints

1.03 CONTRACTOR SUBMITTALS

A. Furnish submittals in accordance with Section 01 33 00– Submittal Procedures.

B. Shop Drawings: Shop Drawings shall contain the following information:

1. Drawings: Layout drawings including necessary dimensions, details, pipe joints, fittings, specials, bolts and nuts, gaskets, valves, appurtenances, anchors, guides, and material lists. Pipe spooling and fabrication drawings shall indicate spacers, adapters, connectors, fittings, and pipe supports to accommodate the equipment and valves in a complete and functional system.
2. Welding Qualifications and Procedures
3. Pipe Supports: Submit pipe support fabrication drawings including calculations in accordance with Section 40 05 07- Hangers and Supports for Process Piping.
4. Grooved joint couplings and fittings shall be shown on drawings and product submittals and shall be specifically identified with the applicable style or series designation, and restraint system if applicable.
5. Thermoplastic Pipe Joints: Submit solvent cement manufacturer's catalog indicating that the recommended product is suitable for each fluid service application.
6. Gasket Material: Submit gasket manufacturer's catalog indicating that the recommended product is suitable for each fluid service application.
7. Seals and Seating Materials: Submit elastomer material and manufacturer's catalog indicating that the recommended product is suitable for each fluid service application.
8. Modular Seals for Pipe: Manufacturer's catalog sheet showing materials and installation procedures.
9. Expansion Joints: Submit detailed calculations and manufacturer's Shop Drawings of proposed expansion joints, piping layouts, and anchors and guides, including information on materials, temperature, and pressure ratings
10. Flexible Connectors: Submit pressure and thermal expansion calculations

C. Samples

1. Performing and paying for sampling and testing as necessary for certifications are the Contractor's responsibility.

D. Certifications

1. Necessary certificates, test reports, and affidavits of compliance shall be obtained by the Contractor.
2. A certification from the pipe fabricator that each pipe will be manufactured subject to the fabricator's or a recognized Quality Control Program. An outline of the program shall be submitted to the Engineer for review prior to the manufacture of any pipe.

1.04 MATERIAL DELIVERY, STORAGE, AND PROTECTION

- A. Piping materials, fittings, valves, and accessories shall be delivered in a clean and undamaged condition and stored off the ground for protection against oxidation caused by ground contact.
- B. Defective or damaged materials shall be replaced with new materials.

PART 2 -- PRODUCTS

2.01 GENERAL

A. Extent of Work

1. Pipes, fittings, and appurtenances shall be provided in accordance with the requirements of the applicable Sections of Divisions 33 and 40 and as indicated.
2. Materials in contact with potable water or process water that be deemed potable

B. Piping Supports

1. Pipes shall be adequately supported, restrained, and anchored in accordance with Section 40 05 07 – Hangers and Supports for Process Piping, and as indicated.
2. Piping support seismic and wind loads shall be sized in accordance with the design criteria as specified in Section 01 33 17 – Structural Design, Support and Anchorage.

C. Lining

1. Application, thickness, and curing of pipe lining shall be in accordance with the applicable Sections of Division 33, unless otherwise indicated.

D. Coating

1. Application, thickness, and curing of coating on buried pipe shall be in accordance with the applicable Sections of Division 33 and Section 09 96 00 - High-Performance Coatings , unless otherwise indicated.
2. Pipes above ground or in structures shall be coated in accordance with Section 09 96 00 – High-Performance Coatings.

E. Pressure Rating

1. Piping systems shall be designed for the pressure as defined in respective pipe sections, or as indicated on the Piping Schedule, whichever is greater.

F. Inspection

1. Pipe shall be subject to inspection at the place of manufacture.
2. During the manufacture, the Engineer shall be given access to areas where manufacturing is in progress and shall be permitted to make inspections necessary to confirm compliance with requirements.

G. Tests

1. Except where otherwise indicated, materials used in the manufacture of the pipe shall be tested in accordance with the applicable specifications and standards.
2. Welds shall be tested as indicated.
3. The Contractor shall be responsible for performing material tests.

H. Welding Requirements

1. Qualification of welding procedures used to fabricate pipe shall be in accordance with the provisions of AWS D1.1 - Structural Welding Code or the ASME Boiler and Pressure Vessel Code, Section 9, whichever is applicable.

I. Welder Qualifications

1. Welding shall be performed by skilled welders and welding operators who have adequate experience in the methods and materials to be used.
2. Welders shall be qualified under the provisions of AWS D1.1 or the ASME Boiler and Pressure Vessel Code, Section 9, whichever is applicable.
3. Machines and electrodes similar to those used in the Work shall be used in qualification tests.
4. Qualification testing of welders and materials used during testing is part of the Work.

2.02 PIPE FLANGES

A. General

1. Flanges shall be provided with flat faces and shall be attached with bolt holes straddling the vertical axis of the pipe unless otherwise indicated.
2. Flange faces shall be perpendicular to the axis of the adjoining pipe.
3. Flanges for miscellaneous small diameter pipes shall be in accordance with the standards indicated for those pipes.

B. Pressure Ratings

1. 150 psig or less: Flanges shall conform to either AWWA C207 - Steel Pipe Flanges for Waterworks Service--Sizes 4 In. Through 144 In., Class D, or ASME B16.5 - Pipe Flanges and Flanged Fittings, Class 150.
2. 150 psig to 275 psig: Flanges shall conform to either AWWA C207 Class E or Class F, or ASME B16.5, Class 150.
3. 275 psig to 700 psig: Flanges shall conform to ASME B16.5, Class 300.
4. Selection Based on Test Pressure
 - a. Do not expose AWWA flanges to test pressures greater than 125 percent of rated capacity.
 - b. For higher test pressures, the next higher rated AWWA flange or an ANSI-rated flange shall be selected.

C. Blind Flanges

1. Provide blind flanges in accordance with AWWA C207, or as indicated for miscellaneous small pipes.
2. Blind flanges for pipe diameters 12 inches and greater shall be provided with lifting eyes in the form of welded or threaded eye bolts.

D. Flange Coating

1. Machined faces of metal blind flanges and pipe flanges shall be coated with a temporary rust-inhibitive coating to protect the metal until the installation is completed.

E. Flange Fasteners

1. Unless otherwise shown on the drawings, or indicated in the applicable Sections of Divisions 33 and 40, Bolts and nuts shall conform to the following requirements;
 - a. Threads shall be in accordance with ANSI/ASME B1.1, Class 2, UNC for bolt diameters 1" and smaller and UN8 for bolt diameters greater than 1".
 - b. Bolts shall have heavy hexagon heads and heavy hexagon nuts. Length of studs shall provide a projection of not less than 0.25 inch and no more than 0.5 inch through the nut when it is drawn tight.
 - c. Thread studs on flange connections are not permitted except where space restrictions preclude the use of standard bolts and where approved by the Engineer.
 - d. Through bolt holes shall be drilled in accordance with the applicable flange standard.

- e. All bolts fastening metallic flanges shall be provided with plain washers installed under the nut. Washer materials shall be of the same material as the bolt. If the through bolt holes are drilled larger than the applicable standard by 1/8 inch in diameter or more, bolts shall be also installed with a plain washer under the bolt head as well.
 - f. All bolts fastening non-metallic flanges shall be provided with plain washers installed under both the bolt head and nut.
 - g. Washer materials shall be of the same material as the bolt.
 - h. Anti-seize compound shall be used on carbon steel fasteners, and shall be Husk-ITT, Husky 2000; or equal.
 - i. Anti-galling compound used for stainless steel fasteners in LOX, nitrogen injection, oxygen, ozone process/off-gas/vent and ozone contactor maintenance air service shall be DuPont "Krytox"; or equal.
 - j. Anti-galling compound used for stainless steel fasteners for other services shall be certified for potable water use and shall be Husk-ITT, Lube O'seal; Hercules, Real-Tuff; La Co, Slic-Tite; or equal.
2. Fastener Material Group Numbering System
- a. Flange fasteners shall conform to the following material standards and shall be categorized within the Fastener Material Schedule Groups as indicated:
 - 1) Material Group C1 (Carbon steel): ASTM A307 Grade B bolts, ASTM A563 Grade B nuts with ASTM F436 washers
 - 2) Material Group C2 (Carbon steel): ASTM A193 Grade B7 bolts, ASTM A194 Grade 2H nuts with ASTM F436 washers
 - 3) Material Group S1 (316 SS): ASTM A193, Grade B8M bolts, ASTM A194 Grade 8M nuts with Type 316 SS plain washers.
 - 4) Material Group S2 (304 SS): ASTM A193, Grade B8 bolts, ASTM A194 Grade 8F nuts with Type 304 SS plain washers.
 - 5) Material Group S3 (Hastelloy C-276): ASTM F468 N10276 bolts ASTM F467 N10276 nuts with type Hastelloy plain washers.
3. Fastener Material Group Numbers used in Non-Corrosive Service Applications
- a. AWWA C115 ductile iron flanges - Material Group C1
 - b. AWWA C207 steel flanges - Material Group C2
 - c. ASME B31 group piping flanges – Material Group C2
 - d. Non-metallic pipe flanges - Material Group S1

- e. Stainless steel pipe flanges and all others not listed above - Material Group S1
- f. Where mating flanges are of different flange material standards and the specified Fastener Material Groups are in conflict, then fasteners of the higher grade shall be utilized unless otherwise indicated. For the purpose of this requirement, the Material Groups in order of decreasing grade shall be S1, C2, C1. Provide insulating flange sets for dissimilar metal flanged piping to electrically isolate the dissimilar piping.
- g. Where gaskets of Teflon or Viton-A are required, fasteners of Material Group C2 shall be utilized for all C1 flange standards.

4. Fastener Material Group Numbers used in Corrosive Service Applications

- a. All Flange fasteners shall be of Material Group S1 unless S2 and S3 are otherwise indicated on the drawings.

F. Insulating Flanges

- 1. Insulated flanges shall be provided with bolt holes 1/4-inch diameter greater than the bolt diameter.

G. Insulating Flange Sets

- 1. In order to prevent corrosion, insulating flange sets shall be furnished on all piping connections where two dissimilar metals are to be connected. Each insulating flange set shall consist of an insulating gasket, insulating sleeves and washers, and a steel washer.
- 2. For bolt diameters 1-1/2 inches or smaller, insulating sleeves and washers shall be one piece and shall be made of acetyl resin.
- 3. For bolt diameters larger than 1-1/2 inches, insulating sleeves and washers shall be 2-piece and shall be made of polyethylene or phenolic material.
- 4. Insulating flange sets materials used for fluids other than general water and wastewater shall be made of materials compatible with the fluid services.
- 5. Insulating gaskets shall be full-face.

H. Insulating Flange Manufacturer, or Equal

- 1. JM Red Devil, Type E
- 2. Fluid Sealing Products, Inc.
- 3. Enpro Industries, Inc. (GPT)

I. Flange Gaskets

1. Gaskets for flanged joints used in general water and wastewater service shall be full faced type in accordance with AWWA C207, suitable for temperatures to 700 degrees F, a pH of one to 11, and pressures to 1000 psig.
2. Blind flanges shall be provided with gaskets covering the entire inside face of the blind flange and shall be cemented to the blind flange.
3. Ring gaskets will not be accepted unless otherwise indicated.
4. Unless otherwise indicated, flange gaskets up to 150 psi shall be EPDM sheet material, NSF 61 approved, **Garlock, Style 98206-U (unbranded), or similar products from John Crane, or equal.**
5. Unless otherwise indicated, flange gaskets up to 500 psi shall be aramid fiber with rubber binder material, NSF 61 approved, **Garlock, Style 3760-U (unbranded), or similar products from John Crane, or equal.**
6. Gaskets for flanged joints used in water with chloramines shall be Teflon material, NSF 61 approved, **Garlock, Gylon Style 3505, or similar products from John Crane, or equal.**
7. Gaskets for flanged joints used in water with ozone shall be Teflon material, NSF 61 approved, **Garlock, Gylon, Style 3504, or similar products from John Crane, or equal.**
8. Gaskets for flanged joints used in cryogenic oxygen (LOX and GOX) service shall be Teflon material, **Garlock Gylon, Style 3502 and 3503 or similar products from John Crane, or equal.**
9. Gaskets for flanged joints in PVC and CPVC piping used in general water and wastewater service shall be NSF 61 approved, full-faced, 1/8-inch thick, and made of fluoroelastomer having a durometer hardness of 50 to 70. Gaskets for pipe sizes up to 24-inch and 150 psi shall be Garlock Style XP or similar products from John Crane, or equal.
10. When the mating flange has a raised face, provide stainless steel flat ring gasket filler between the PVC flange and gasket and the adjacent flange.
11. Gaskets for flanged joints used in chemicals, hot air, ozone gas, solvents, hydrocarbons, steam, chlorine and other fluids shall be made of materials compatible with the service, pressure, and temperature. Consult gasket Manufacturer for recommended gasket material.

2.03 PIPE THREADS

- A. Pipe threads shall be in conformance with ASME B1.20.1 - Pipe Threads, General Purpose (inch), and be made up with Teflon tape unless otherwise indicated.
- B. Unless otherwise indicated, use metal FNPT and plastic MNPT for threaded pipe connections between metal and plastic pipes.

2.04 THREADED INSULATING CONNECTIONS

A. General

1. Threaded insulating bushings, unions, or couplings, as appropriate, shall be furnished for joining threaded pipes of dissimilar metals and for piping systems where corrosion control and cathodic protection are involved.

B. Materials

1. Threaded insulating connections shall be constructed of nylon, Teflon, polycarbonate, polyethylene, or other non-conductive materials, and shall have ratings and properties to suit the service and loading conditions.

2.05 MODULAR MECHANICAL SEALS FOR PIPING PENETRATIONS

- A. Where indicated and where required in order to prevent flow of water or air, the passages of piping through wall sleeves and cored openings shall be sealed with modular interlocking link mechanical closures.
- B. Individual links shall be constructed of EPDM rubber, be suitable for temperatures between minus 40 and plus 250 degrees F and be shaped to fill the annular space between the outside of the pipe and the inside of the wall sleeve or cored opening.
- C. Assemble the links using Type 316 stainless steel bolts and nuts to form a continuous rubber belt around the pipe.
- D. Pressure plates under each bolt and nut shall be fabricated of a corrosion-resistant composite material.
- E. After the seal assembly is positioned in the sleeve, tighten the bolts against the pressure plates to expand the rubber links and form the watertight seal.
- F. Sizing and installation of sleeves and assemblies shall be in accordance with the manufacturer's recommendations.
- G. Modular Mechanical Seals Manufacturer, or Equal
 1. EnPro Industries Company (GPT), Link-Seal
 2. Proco Products, Inc., Pen-Seal

2.06 AIR AND GAS TRAPS

- A. Air and gas pipes shall slope to low points and shall be provided with drip legs, shut-off valves, strainers, and traps.
- B. Pipe the traps to the nearest drain.
- C. Air and gas traps shall be not less than Class150 iron body float-type, with a copper or stainless-steel float.

D. Bracket, lever, and pins shall be constructed of stainless steel.

E. Drain traps shall be provided with threaded connections.

F. Air and Gas Traps Manufacturer, or Equal

1. Armstrong International, Inc.

2. Spirax Sarco, Inc.

2.07 CATHODIC PROTECTION

A. Where indicated, buried piping shall be cathodically protected in accordance with the requirements of the Contract Documents.

PART 3 -- EXECUTION

3.01 GENERAL

A. This section specifies the general installation requirements for piping, valves, and related items and shall be installed in accordance with the manufacturer's technical data and printed instructions. Specific piping materials, systems, appurtenances, and related installation and testing requirements are specified in related sections of Divisions 01, 33, and 40, and as noted on the Drawings, Pipe and Valve Schedules.

B. Piping shall be installed in a neat and workmanlike manner, properly aligned and cut from measurements taken at the Site to avoid interferences with structural members, architectural features, openings, and equipment. Exposed pipe shall afford maximum headroom and access to equipment, and where necessary piping shall be installed with sufficient slopes for venting or drainage of liquids and condensate to low points.

C. Contractor shall obtain the assistance of the pipe manufacturer to instruct the pipe fitters in the correct installation and support of the piping system. Valves and flanges attached to the pipe shall be provided with adequate supports.

D. Lined Piping Systems

1. The lining manufacturer shall take full responsibility for the complete, final product and its application.

2. Pipe ends and joints of lined pipes at threaded flanges shall be epoxy-coated in order to assure continuous protection.

3.02 INSTALLATION

A. Installation shall be free from defects. Prior to installation, each pipe length shall be carefully inspected, be flushed clean of any debris or dust, and be straightened if not true straight. Ends of threaded pipes shall be reamed and filed smooth. Groove ends shall be clean and free from indentations, projections, and roll marks in the area from the pipe end to the groove. Fittings shall be equally cleaned before assembly.

- B. Building gravity flow plumbing pipes shall be installed in a neat and workmanlike manner, in accordance with the prevailing plumbing and building codes. Pipes shall have the required slopes for proper drainage. Pipe locations inside buildings shall be coordinated with the rest of the Work to avoid interferences and to provide sufficient headroom. Installations shall be acceptable to the local plumbing inspector.
- C. Supports and Anchors: Piping supports, thrust, and seismic restraints shall be provided where shown on the Drawing or were determined to be required in according to Section 40 05 07- Hangers and Supports for Process Piping. Where necessary to avoid stress on equipment or structural members, the pipe shall be anchored or harnessed. Expansion joints and guides shall compensate for pipe expansion due to temperature differences. Pipe shall be firmly supported with fabricated or commercial hangers or supports.
- D. Piping Joints: Pipe joints requirements shall conform to the applicable piping sections of Division 33 and Division 40.
1. Threaded Joints: Pipe threads shall be full and cleanly cut with sharp dies. Not more than 3 threads shall remain exposed after installation.
 2. Welded Joints: Welded joints shall conform to the specifications and recommendations of ASME B 31.1 - Power Piping. Welding shall be done by skilled and qualified welders. Pipe surface residues, oxides, and heat stains are to be removed from a field weld and the affected areas adjacent by the use of stainless-steel wire brushes. For alloy and stainless-steel pipe, the post welding surfaces shall be cleaned with a pickle agent such as nitric/hydrofluoric acid solutions or pickle paste or equal, then complete removal of the agent by wash the surface thoroughly with clean water.
 3. Flange Joints: Flanged joints shall be made with gaskets with bolts and nuts as specified. Care shall be taken not to over-torque the bolts, in accordance with the manufacturer's written recommendations.
 4. Fusion-Welded Joints: Fusion-welded joints shall be made with the manufacturer's recommended equipment on clean, dry pipe ends. The joints shall be made up at the recommended ambient temperatures, to the pipe manufacturer's written recommendations. The pipe supplier shall be consulted to obtain machinery and expertise for the joining by fusion welded of pipe and fittings. No pipe or fittings shall be joined by fusion by any of the Contractor's personnel unless they are adequately trained and qualified in the techniques involved. Butt fusion joining shall yield a joint strength equal to or greater than the tensile strength of the pipe. Socket fusion, extrusion welding and hot gas welding shall not be used for field connections.
 5. Brazed and Soldered Joints: Brazed and soldered joints shall conform to the manufacturer's recommendations and to the specifications and recommendations of ASME B 31.1 - Power Piping. Brazing shall be done by skilled and qualified welders. Prior to the application of flux, the ends of tubes shall be thoroughly dried and cleaned.

6. Grooved Joints: Grooves for grooved couplings and fittings shall be made with specially designed grooving tools to the manufacturer's recommendations and conform to AWWA C 606 – Joints, Grooved and Shouldered Type. Grooves shall be clean and sharp without flaws, and the pipe ends shall be accurately cut at 90 degrees to the pipe axis.
7. Push On Joints: Push on joints and gasket installation shall be in accordance with the manufacturer's recommendations and lubricants. Pipe ends shall be beveled to facilitate assembly. Lubricants shall be suitable for potable water service and shall be kept clean in closed containers.
8. Solvent-Welded Joints: Solvent-welded joints shall be made with fresh primer and solvent cement on clean, dry pipe ends. The primer and cement cans shall be kept always closed and the joints shall be made up at the recommended ambient temperatures, to the pipe or cement manufacturer's written recommendations. PVC socket connections shall be joined with PVC cement conforming to ASTM D2564 Standard Specification for Solvent Cements for Poly (Vinyl Chloride) (PVC). CPVC socket connections shall be joined with CPVC solvent cement conforming to ASTM F493. For chemical service applications, solvent cement shall be formulated and labeled for use on that chemical.
9. Adhesive Joints: Adhesive joints shall be made with freshly-mixed 2-part epoxy on clean, dry pipe ends per pipe manufacturer recommendations. The joints shall be made up at the recommended ambient temperatures, to the pipe or adhesive manufacturer's written recommendations. Pipe ends shall be inserted to the full depth of the socket.
- E. Valves and Unions: Unless otherwise indicated, connections to fixtures, groups of fixtures and equipment shall be provided with a shutoff valve and union, unless the valve has flanged ends. Unions shall be provided at threaded valves, equipment, and other devices requiring occasional removal or disconnection.
- F. Branch Connections: Branch connections in horizontal runs of air and gas piping shall be made from the top of the pipe, to avoid drainage of condensate into the equipment. Unless otherwise indicated for threaded pipe connections between metal and plastic pipes, use metal FNPT and plastic MNPT.
 1. Pipe ends and joints of lined pipes at threaded flanges shall be epoxy-coated in order to assure continuous protection.
- G. Isolation Joints / Dielectric Protection: Provide electrically isolate connections between dissimilar metal piping connections. Electrical checks shall be made to assure no contact is made between dissimilar metal piping elements.
 1. Use dielectric couplings specially designed for the prevention of galvanic reaction between dissimilar metals.
 2. For flanged connections, use stainless steel bolts with isolation bushings, washers, and full-face flange gaskets.

- H. Core Drilling: Where core drilling is required for pipes passing through existing concrete, core drilling locations shall be determined by radiograph of concrete construction in order to avoid damage to embedded raceways and reinforcing bars.
- I. Coating: Exposed pipes shall be coated with a finish coat to the pipe manufacturer's standard protective coating, with the manufacturer's recommended prime coat and a finish coat in accordance with Section 09 96 00– High-Performance Coatings.
- J. Low points in piping systems and drip legs in steam, gas, and air systems shall have drainage valves.
- K. Care shall be taken to ensure that piping flanges, mechanical-type couplings, sleeve-type couplings, flexible connectors, and expansion joints are properly installed as follows:
 - 1. Gasket surfaces shall be carefully cleaned and inspected prior to making up the connection. Gasket shall be centered properly on the contact surfaces.
 - 2. Connections shall be installed to prevent inducing stress to the piping system or the equipment to which the piping is connected.
 - 3. Contact surfaces for flanges, couplings, and piping ends shall be aligned parallel, concentric, and square to each axis at the piping connections.
 - 4. Flange Bolts
 - a. Flange bolts shall be initially hand-tightened with the piping connections properly aligned.
 - b. Bolts shall be tightened with a torque wrench in a staggered sequence to the recommended torque for the applicable piping material per AWWA or manufacturer's recommendation. Care shall be taken to avoid over-torquing the bolts especially on plastic flanged joints.
 - c. Harness, thrust restraint, and tie rod bolts used for sleeve couplings, flange coupling adapters, or flexible joints shall be tightened gradually and equally at diametrically opposite sides until snug, in order to prevent misalignment and to ensure that all studs carry equal loads.
 - d. In order to prevent induced stress or misalignment, do not over-torque connections to adjoining pump or equipment. Flanges shall not be deformed nor cracked.

3.03 INSPECTION

- A. After completion of the Work, cuttings, joining and wrapping materials, and other scattered debris shall be removed from the Site. The entire piping system shall be in a clean and functional condition.

- B. Inspection: Finished installations shall be carefully inspected for proper joints and supports, interferences, and damage to pipe, fittings, and coating. Temporary plugs and covers shall be removed from openings and floor drains. Defective Work shall be repaired to the satisfaction of the field engineer or plumbing inspector.

3.04 FIELD TESTING FOR PRESSURE PIPING

- A. Prior to enclosure or burying, piping systems shall be pressure tested as required in the Piping Schedule for a period of not less than two hours without exceeding the tolerances listed in the Piping Schedule. Where no pressures are indicated, the pipes shall be subject to 1-1/2 times the maximum working pressure. The Contractor shall furnish test equipment, labor, materials, and devices as part of the Work. For additional testing requirements, refer to Section 33 05 05.50 - Pressure Pipe Testing and Disinfection.
- B. Leakage may be determined by loss of pressure, soap solution, chemical indicator, or other positive and accurate method. Fixtures, devices, or other accessories which are to be connected to the lines and which would be damaged if subjected to the test pressure shall be disconnected and ends of the branch lines plugged or capped as required during the testing procedures.
- C. Leaks shall be repaired, and the system shall be re-tested until no leaks are found.

3.05 FIELD TESTING FOR GRAVITY PLUMBING PIPING

- A. Prior to enclosure or burying, drains and vents shall be tested in the presence of the local plumbing inspector and the Engineer for a period of not less than one hour, or as requested by the plumbing inspector if the request is more stringent. The Contractor shall furnish test equipment, labor, material, and devices as part of the Work. Defective Work shall be repaired to the satisfaction of the plumbing inspector, and the piping shall be re-tested until no leaks are found.
- B. Leakage may be determined by loss of pressure, soap solution, chemical indicator, or other positive and accurate method. Fixtures, devices, or other accessories which are to be connected to the lines and which would be damaged if subjected to the test pressure shall be disconnected and ends of the branch lines plugged or capped as required during the testing procedures.
- C. Testing and defective Work shall be repaired to the satisfaction of the plumbing inspector.

END OF SECTION

SECTION 40 05 02 – PIPING IDENTIFICATION

PART 1 -- GENERAL

1.01 THE SUMMARY

- A. The Contractor shall provide identification for the piping and valves, complete and in place, in accordance with the Contract Documents.

1.02 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

A. Reference Specifications

01 33 00	Submittal Procedures
09 96 00	High-Performance Coatings

B. Commercial Standards

American Society of Mechanical Engineers (ASME)	
ASME A13.1	Scheme for the Identification of Piping Systems

1.03 CONTRACTOR SUBMITTALS

- A. Furnish submittals in accordance with Section 01 33 00– Submittal Procedures.
- B. Shop Drawings: Provide a list of the suggested wording for each pipe label and valve tag, prior to fabrication.
- C. Samples
1. Sample of each type of identification device.
 2. Sample of each proposed color required by the pipe color schedule.

PART 2 -- PRODUCTS

2.01 EXPOSED PIPING OR ABOVE GROUND PIPING IDENTIFICATION

- A. Pipe markers, type as indicated below, suitable for outdoor application from -40 degrees to 180 degrees Fahrenheit; in accordance with ASME A13.1 requirements.
1. Marker Type
 - a. Snap Around: Vinyl or polyester sheet with UV- resistant ink, pre-shaped and sized to tightly curl around the pipe and remain in position.
 - b. Adhesive: Vinyl or polyester sheet with UV- resistant ink, shaped similar to pipe curvature and coated with pressure sensitive adhesive.
 - c. Stencil: Lettering painted directly on surface of pipe inside color coded marker area.
 2. Marker Area: Sized per pipe size according to ASME A13.1 and conforming to the color codes in the Identification Colors table below.

3. Lettering: Sized per pipe size according to ASME A13.1 and conforming to the color codes in the Identification Colors table below.
 4. Arrows: At least one arrow at each marker area, showing direction of flow.
- B. Pipe 1-inch diameter and smaller or pipe not suitable for the marker type(s) listed above shall be identified with aluminum or stainless-steel pipe identification tags with stamped-in ¼" high identification lettering.
- C. Manufacturer or Equal
1. Seton Identification Products, Opti Code Pipe Markers (adhesive type)
 2. Grainger, Inc. (adhesive, snap around)
 3. Marking Services, Inc.(adhesive, snap around)

2.02 BURIED PIPELINE IDENTIFICATION

A. Underground Warning Tape

1. Material:
 - a. Polyethylene tape or polyolefin film. The material and ink shall be chemically inert and shall not degrade when exposed to acids, alkalis and other destructive substances commonly found in soil.
 - b. 6" wide tape with a minimum 4 mil thickness.
 - c. Message: "CAUTION, LINE BURIED BELOW" with the name of the fluid service in black lettering on a colored background.
 - 1) Water: Blue
 - 2) Sewer: Green
 - 3) Gas and other services: Yellow
 - 4) Other services: colors as approved by the Owner.
2. Manufacturer, or Equal
 - a. Reef Industries, Inc.
 - b. Seton Identification Products
 - c. T. Christy Enterprises, Inc.

B. Tracer Wire

1. Material:
 - a. Solid copper conductor with 30 mil HMWPE.
 - b. 10 gauge or thicker wire.
2. Manufacturer, or Equal

- a. Kris-Tech Wire
- b. Corrpro Companies, Inc.

C. Witness Markers

1. Material:

- a. UV resistant glass fiber and resin reinforced thermosetting composite material.
- b. Constructed as a single pipe with pointer at the bottom end.
- c. Message of the markers "CAUTION, LINE BURIED BELOW" with the name of the fluid service, and the following information:
 - 1) Phone number for underground service alert.
 - 2) Phone number for Owner in case of emergency.
 - 3) Application station number and offset information if marker is not directly over the pipe.
 - 4) Name of buried appurtenance or fitting if applicable.

2. Manufacturers, or Equal

- a. Carsonite® Composite Utility Marker
- b. Berntsen International, Inc.

2.03 EXISTING IDENTIFICATION SYSTEMS

- A. In installations where existing piping identification systems have been established, the Contractor shall follow the existing system. Where existing identification systems are incomplete, utilize the existing system as far as practical and supplement with the system indicated herein.

2.04 IDENTIFICATION OF VALVES AND SHORT PIPE LENGTHS

- A. Valves and sections of pipe that are too short to be identified with markers and arrows shall be identified with metal or plastic tags.
- B. Metal tags shall be stainless steel with embossed lettering. Plastic tags shall be solid black plastic laminate with white embossed letters. Tags shall be designed to be firmly attached to the valves or short pipes or to the structure immediately adjacent to the valves or short pipes.
- C. Wording on valve tags shall describe the exact function of each valve (e.g., "HWR-BALANCING," "CLS THROTTLING", "RAS-PUMP SHUT-OFF," etc.) and include the valve number as indicated in the Contract Drawings. Wording on small pipes shall describe the contents of the pipe.

2.05 PIPE COATING:

- A. Unless otherwise indicated, pipe coating shall be in conformance with Section 09 96 00– High-Performance Coatings.

PART 3 -- EXECUTION

3.01 GENERAL

- A. Markers and identification tags shall be installed in accordance with the manufacturer's printed instructions and shall be neat and uniform in appearance. Tags and markers shall be readily visible from all normal working locations.

3.02 VALVE TAGS

- A. Valve tags shall be permanently attached to the valve or structure by means of 2 stainless steel bolts or screws.

3.03 MARKER LOCATIONS

- A. Each pipe shall be marked at:
 - 1. Intervals of 20-feet in straight runs.
 - 2. At least once in every room.
 - 3. Within 2 feet of turns, elbows, and valves.
 - 4. On the upstream side of tees, branches, and other distribution points.
 - 5. On both sides of walls and floors through which the piping passes.

3.04 IDENTIFICATION COLORS B. NEW 2015 COMBINED PIPE SCHEDULE .

A. Conform to the following color codes.

Pipe Contents		Marker Color	Letter Color	Pipe Color
Symbol	Service			
DR	Drain	green	white	
DWR	Domestic Hot Water Return	green	white	
DWS	Domestic Hot Water Supply	green	white	
FOR	Fuel Oil Return	brown	white	
FOS	Fuel Oil Supply	brown	white	
FP	Fire Protection	red	white	
FW	Finished Water	green	white	
HR	Heating Water Return	green	white	
HS	Heating Water Supply	green	white	
IA	Instrument Air	blue	white	
LSP	Landscaping Sprinkler System	green	white	
MG	Methane Gas	yellow	black	
NG	Natural Gas	yellow	black	
OF	Overflow	green	white	
OG	Off-Gas	orange	black	
PW	Potable Water	green	white	
SAM	Rainwater Leader	green	white	
SD	Sanitary Drain	green	white	
SDR	Storm Drain	green	white	
SPD	Sump Pump Discharge	green	white	
SS	Sanitary Sewer	green	white	
V	Vacuum	blue	white	
VT	Vent	blue	white	

END OF SECTION

**SECTION 40 05 06 – COUPLINGS, ADAPTERS, AND SPECIALS FOR PROCESS
PIPING**

PART 1 -- GENERAL

1.01 THE SUMMARY

- A. The Contractor shall provide pipe couplings indicated, complete and operable, in accordance with the Contract Documents.
- B. The requirements of Section 40 05 01 - Piping General apply to the Work of this Section
- C. The provisions of this Section shall apply to piping in Divisions 33 and 40, and on the Drawings.
- D. The couplings, adapters and joints shall be provided with restraining devices to restrict pipe axial movement. Where the restraining devices and/or details are not indicated on the Drawings, it is the Contractor's responsibility to provide the devices/details necessary to restrain the piping system.
- E. The Items specified in this section include the following:
 - 1. Groove Couplings
 - 2. Sleeve Couplings
 - 3. Flanged Coupling Adapters
 - 4. Dismantling Joints
 - 5. Expansion Joints
 - 6. Flexible Connectors
 - 7. Transition Couplings
 - 8. Quick Disconnect Couplings
 - 9. Tapping Sleeves
 - 10. Miscellaneous Adapters

1.02 CONTRACTOR SUBMITTALS

- A. Furnish submittals in accordance with Section 01 33 00– Submittal Procedures.
- B. Shop Drawings: Shop Drawings shall contain the following information:
 - 1. Product submittals and shall be specifically identified with the applicable style or series designation, pressure rating and restraint system if applicable.
 - 2. Couplings schedule or layout indicating where the couplings will be installed.

3. Expansion Joints: Submit detailed calculations and manufacturer's Shop Drawings of proposed expansion joints, piping layouts, and guides, including information on materials, temperature, and pressure ratings
4. Flexible Connectors: Submit pressure and thermal expansion calculations

C. Certifications

1. Necessary certificates, test reports, and affidavits of compliance shall be obtained by the Contractor.

1.03 MATERIAL DELIVERY, STORAGE, AND PROTECTION

- A. Piping couplings, adapters, and joints accessories shall be delivered in a clean and undamaged condition and stored off the ground for protection against oxidation caused by ground contact.
- B. Defective or damaged materials shall be replaced with new materials.

1.04 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

A. Reference Specifications

01 33 00	Submittal Procedures
09 96 00	High-Performance Coatings
40 05 01	Piping General

B. Reference Standards

American Iron and Steel Institute (AISI)	
AISI 1012	Carbon Steel
ASTM A512	Cold-Drawn Butt-Weld Carbon Steel Mechanical Tubing
ASTM A513	Electric-Resistance Welded Carbon and Alloy Steel Mechanical Tubing
ASTM A 576	Steel Bars, Carbon, Hot Wrought, Special Quality
American Water Works Association (AWWA)	
AWWA C207	Standard for Steel Pipe Flanges for Waterworks Service, Sizes 4 in. through 144 in.
AWWA C219	Bolted Sleeve-Type Couplings for Plain-End Pipe
AWWA C606	Grooved and Shouldered Joints
AWWA M11	Steel Pipe: A Guide for Design and Installation

PART 2 -- PRODUCTS

2.01 GENERAL

A. Extent of Work

1. Piping couplings, adapters, joints, and accessories shall be provided in accordance with the requirements of the applicable Sections of Divisions 33 and 40 and as indicated.

2. The Contractor shall not be allowed to substitute any other type of coupling in lieu of the couplings as specified herein unless approved by the Engineer.
3. The Contractor shall assign the responsibility to the coupling manufacturer to review the piping connection to the equipment and submit any modifications to the Engineer for review.

B. Pressure Rating

1. Couplings, adapters, and joints shall be designed for the pressure as defined in respective pipe sections.

C. Seals

1. Seal elastomer materials shall be selected to be compatible with the fluid service, pressure, and temperature. They shall be composed of elastomeric-compound material that will not deteriorate from age under normal storage or use conditions.

D. Coating

1. Couplings shall be lined and coated at the factory, unless otherwise indicated.
2. Coating shall be in accordance with the Section 09 96 00– High-Performance Coatings, unless otherwise indicated.

2.02 GROOVED TYPE COUPLINGS

A. General

1. Provide cast grooved type couplings where indicated, conforming to the requirements of AWWA C606 - Grooved and Shouldered Joints.
2. Grooved or banded piping shall conform to the coupling manufacturer's recommendations to suit the highest expected pressure.
 - a. If grooved connections are used, the remaining thickness of pipe material after grooving shall be adequate to carry the load imparted to the joint. Joints for thin wall pipes shall be banded or welded with a collared end to fit coupling.
 - b. Rolled pipe ends are not acceptable as a means of connection for metallic piping.
3. Equipment connections with mechanical-type couplings shall be provided with rigid grooved couplings or flexible type coupling with harness in sizes where rigid type couplings are not available, unless thrust restraint is provided by other means.
4. Couplings shall be electrically bonded.
5. For uniformity and compatibility of the piping components; grooving tools, grooved fittings, couplings, and valves shall be furnished by the same manufacturer as the coupling.

B. Grooved Type Couplings Manufacturer, or Equal

1. Grooved couplings for ductile iron piping shall be provided with flush seal gaskets.

- a. Victaulic Company, Style 31 (flexible or rigid)
 - b. Gustin-Bacon (banded or grooved)
- 2. Grooved couplings for steel piping
 - a. Victaulic Company, Style 177 / 77 / W77 (grooved, flexible, or rigid)
 - b. Victaulic Company, Style 107H / 07 / W07 or HP-70 (grooved, rigid)
 - c. Gustin-Bacon (banded or grooved)
- 3. Grooved couplings for stainless steel piping
 - a. Victaulic Company, Style 489 (rigid)
 - b. Victaulic Company, Style 77S (flexible)
 - c. Gustin-Bacon (banded or grooved)

2.03 SLEEVE COUPLINGS

A. General

- 1. Provide sleeve couplings specifically designed suitable for the fluid service and pressure rating.

B. Construction

- 1. Sleeve couplings shall be in accordance with AWWA C219 - Standard for Bolted Sleeve-Type Couplings for Plain-End Pipe.
- 2. Couplings shall be constructed without pipe stop.
- 3. The middle ring shall be at least the same wall thickness as the pipe to which the coupling is connected and not less than 1/4-inch thick.
- 4. If the strength of the middle ring material is less than the strength of the pipe material, the thickness of the middle ring shall be increased to have the same strength as the pipe.
- 5. For standard sleeve couplings, the coupling shall be either 5 or 7 inches long for pipe diameters up to and including 30-inch and 10 inches long for pipe diameters greater than 30-inch. For long sleeve couplings, the coupling shall be 16 inches long for all pipe diameters.
- 6. The followers shall be single-piece contoured mill sections welded and cold-expanded as required for the middle rings and of sufficient strength to accommodate the number of bolts necessary to obtain adequate gasket pressures without excessive rolling.

C. Insulating Sleeve Couplings

1. Where insulating couplings are required, both ends of the coupling shall be provided with a wedge-shaped gasket which assembles over a sleeve of an insulating compound material compatible with the fluid service in order to obtain insulation of coupling metal parts from the pipe.

D. Sleeve-Type Couplings Manufacturer, or Equal

1. World Wide Metric, Inc. (Dresser), Style 38
2. Ford Meter Box Company, Inc., Style FC1 or FC3
3. Smith-Blair, Inc., Style 411

2.04 FLANGED COUPLING ADAPTERS

A. Provide flanged coupling adapters specifically designed suitable for the fluid service and pressure rating.

B. Construction

1. Coupling bodies shall be fabricated from steel, ASTM A512 - Cold-Drawn Butt-Weld Carbon Steel Mechanical Tubing or ASTM A513 - Electric-Resistance Welded Carbon and Alloy Steel Mechanical Tubing.
2. Provide flanges in conformance with AWWA C207.
3. The body shall be at least the same wall thickness as the pipe to which the coupling is connected, but not less than 1/4 inch thick.
4. If the strength of the body material is less than the strength of the pipe material, the thickness of the middle ring shall be increased to have the same strength as the pipe.
5. The follower flange shall be fabricated from steel, ASTM A576 - Steel Bars, Carbon, Hot Wrought, Special Quality or AISI C1012 – Carbon Steel.

C. Flanged Couplings Adapter Manufacturer, or Equal

1. Smith-Blair, Inc., Model 913
2. Dresser®, Style 128-W
3. JCM Industries, Inc., Model 303

2.05 DISMANTLING JOINTS

A. Provide dismantling joints products specifically designed suitable for the fluid service and pressure rating.

B. Construction

1. Coupling bodies shall be fabricated from steel, ASTM A 512 - Cold-Drawn Butt-Weld Carbon Steel Mechanical Tubing or A 513 - Electric-Resistance Welded Carbon and Alloy Steel Mechanical Tubing.

2. Provide flanges in conformance with AWWA C207.
3. The body shall be at least the same wall thickness as the pipe to which the coupling is connected, but not less than 1/4 inch thick.
4. If the strength of the body material is less than the strength of the pipe material, the thickness of the middle ring shall be increased to have the same strength as the pipe.
5. The follower flange shall be fabricated from steel, ASTM A 576 - Steel Bars, Carbon, Hot Wrought, Special Quality or AISI C1012 – Carbon Steel.

C. Dismantling Joints Manufacturer, or Equal

1. Smith-Blair, Inc., Model 975
2. Dresser®, Style 131
3. JCM Industries, Inc., Model 309

2.06 EXPANSION JOINTS

- A. Piping subject to expansion and contraction shall be provided with sufficient means to compensate for such movement without exertion of undue forces to equipment or structures, accomplished with expansion loops, bellow-type expansion joints, or sliding-type expansion joints.
- B. Expansion joints shall be provided with flanged ends and constructed of stainless steel, Monel, rubber, or other materials best suited for each individual service. Where expansion joints are used in water containing dissolved ozone residual or chloramines, provide Type 316 stainless-steel expansion joints.
- C. Where bellows-type expansion joints are mounted near the suction nozzle of the pump, a stainless-steel internal liner shall be provided to minimize turbulence as the flow passes through the arches of the bellows.
- D. Expansion joints for Plastic Tanks
 1. Expansion joints for piping connections to polyethylene tanks nozzles shall be provided by the tank manufacturer, selected for the fluid service, and sized for up to 4% tank expansion or movement as required by the tank manufacturer. Fastener hardware shall be of Type 316 stainless steel construction.
 2. Expansion joints for other plastic tanks shall be constructed of molded PTFE with at least two convolutions and flanged joints. Flanges shall be ductile iron with Type 316 stainless steel bolts and nuts. Flexible connectors shall be **Proco Series 442 molded expansion joint, or equal.**

2.07 FLEXIBLE CONNECTORS

A. Low-Temperature

1. Flexible connectors shall be installed in piping connections to engines, blowers, compressors, and other vibrating equipment, and where indicated.

2. Flexible connectors for service temperatures up to 180 degrees F shall be flanged-reinforced neoprene or butyl spools, rated for a working pressure of 40 to 150 psig, or reinforced flanged duck and rubber, as best suited for the application.
3. Flexible connectors for service temperatures above 180 degrees F shall be flanged, braided stainless steel spools with inner, annular, corrugated stainless steel hose, rated for a minimum 150-psig working pressure, unless otherwise recommended by the equipment manufacturer.
4. The connectors shall be a minimum of 9 inches long and provided with face-to-face flanges, unless otherwise indicated.
5. The final material selection shall be approved by the manufacturer.

2.08 TRANSITION COUPLINGS

- A. Provide transition-coupling products specifically designed suitable for the fluid service and manufactured for the piping applications.
- B. The transition couplings shall have function and design similar to the flexible couplings, joint and flanged coupling adapters for connecting piping having different outside diameters.

2.09 QUICK DISCONNECT COUPLINGS

- A. Quick disconnect couplings shall be of the cam lock type (cam and groove type) consisting of a male adapter conforming to Specification MIL A-A-59326A. Male adapters shall be designed to receive a female coupler without requiring threading, bolting, or tools. Connections shall remain tight and leak proof up to full system pressures.
- B. Each adapter shall be furnished with a dust cap complete with an 18-in long security chain of corrosion resistant material.
- C. Unless otherwise indicated, the quick disconnect couplings shall be flanged connection to piping and materials shall be Type 316 stainless steel.
- D. Quick connect couplings shall be as manufactured by **LMC-Couplings; Dover Corporation; Ever-Tite Coupling Products**; or equal.

2.10 TAPPING SLEEVES

- A. Provide tapping sleeve products specifically designed suitable for the fluid service and manufactured for the piping applications
- B. Unless otherwise indicated, the tapping sleeves shall be of full circumference band with flanged outlet connection sized to ANSI class 150. Material of construction for the body and fastener shall be stainless steel.
- C. Gasket material: Nitrile (Buna-N) or EPDM.
- D. Tapping sleeves shall be as manufactured by **Smith-Blair Inc.; Romac Industries Inc.; Dresser®**, or equal.

2.11 MISCELLANEOUS ADAPTERS

- A. A special pipe adapter may be required to provide proper connection between different type of pipes and/or fittings. The adapter may be indicated on the Drawing with the pipe type or equipment. However, it is the Contractor's responsibility to ensure proper connection between various type of pipes and pipe appurtenances. Provide adapters as required whether specifically indicated or not.
- B. Provide piping adapter products specifically designed suitable for the fluid service and manufactured for the piping applications.

PART 3 -- EXECUTION

3.01 GENERAL

- A. Installation, inspection, and field testing of the pipes shall in accordance with the requirements of Section 40 05 01 - Piping General.
- B. The Contractor shall have the coupling manufacturer's service representative verify the correct choice and application of couplings and gaskets, and the workmanship, to assure a correct installation.
- C. The Contractor shall assign the responsibility to the couplings manufacturer to review the piping connection to the couplings and submit any modifications to the Engineer for review.

3.02 INSTALLATION

- A. Where couplings are shown to connect piping to mechanical equipment such as pumps, compressors, and blowers, the piping shall be aligned with the equipment point of connection and shall be perpendicular to the axis of the flange or fitting for which the piping is to be connected.
- B. The couplings or the piping shall not impose excessive stress to the equipment connection to cause misalignment of the equipment.
- C. Restrained Joints on couplings, adapters, and joints
 - 1. Couplings, adapters, and joints on pressure lines shall be harnessed unless thrust restraint is provided by other means.
 - 2. Harnesses shall be designed by the pipe manufacturer in accordance with AWWA M11, or as indicated.
 - 3. Harness sets shall be designed for the maximum test pressure of the pipe in which they are installed.
 - 4. Where harness sets are installed near the suction and discharge of the pump, harness bolts shall have zero elongation in order to prevent misalignment of the pump imparted by the thrust within the piping system.
 - 5. Other means of restraining the coupling such as set screws on piping will not be accepted.

END OF SECTION

SECTION 40 05 07 – HANGERS AND SUPPORTS FOR PROCESS PIPING

PART 1 -- GENERAL

1.01 THE SUMMARY

- A. The Contractor shall provide pipe supports, hangers, guides, and anchors, complete and in place, as indicated in accordance with the Contract Documents.
- B. Where pipe support systems are not indicated on the Drawings, the Contractor shall design and provide the supports in accordance with this Section. The absence of pipe supports and details on the contract drawings does not relieve the Contractor of responsibility for sizing and providing the pipe supports.
- C. The provisions of this Section shall apply to piping in Divisions 33 and 40.
 - 1. The Contractor shall provide supporting devices for supporting and restraining piping as indicated on the Drawings. Where pipe support devices and/or restraining details are not indicated on the Drawings, it is the Contractor's responsibility to develop the details necessary to support and restrain the piping for a complete and functional pipe support system.
- D. Seismic and Wind Forces
 - 1. Pipe support details indicated in the Contract Drawings are sized for gravity loads only, and not designed to resist seismic and wind forces.
 - 2. The Contractor shall arrange for the services of a registered professional engineer experienced in pipe support design to design such pipe supports to resist seismic and wind forces.
 - 3. Piping support seismic and wind loads shall be sized in accordance with Section 01 33 17– Structural Design, Support and Anchorage.

1.02 CONTRACTOR SUBMITTALS

- A. Furnish submittals in accordance with the requirements of Section 01 33 00– Submittal Procedures.
- B. Shop Drawings
 - 1. Submit Shop Drawings which shall include the following information:
 - a. Drawings of pipe supports, hangers, anchors, and guides.
 - b. Pipe support schedule or layout indicating where the supports will be installed.
 - c. Calculations for special supports and anchors, stamped and signed by a registered professional engineer in the state where the project is located.

1.03 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

- A. Reference Specifications

01 33 00	Submittal Procedures
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01 33 17	Structural Design, Support and Anchorage
05 50 00	Metal Fabrications
09 96 00	High-Performance Coatings
40 05 01	Piping General

B. Reference Standards

American Society of Mechanical Engineers (ASME)	
ASME B31.1	Power Piping
ASTM International (ASTM)	
ASTM A123	Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
Manufacturers Standardization Society of the Valve and Fittings Industry (MSS)	
ANSI/MSS SP-58	Pipe Hangers and Supports - Materials, Design and Manufacture, Selection, Application, and Installation

PART 2 -- PRODUCTS

2.01 GENERAL REQUIREMENTS

A. Code Compliance

1. Piping systems and pipe connections to equipment shall be properly anchored and supported in order to prevent undue deflection, vibration, and dislocation due to seismic events, line pressures, pipe weight, fluid weight, liquid movement, thermal changes, vibration, and probable forces applied during construction as well as stresses on piping, equipment, and structures.
2. Supports and parts thereof shall conform to the requirements of ASME B31.1 - Power Piping – Chapter II, Part 5 -Expansion, Flexibility, and Pipe Supporting Element and design the pipe supporting elements in accordance with the rules of MSS SP-58 -Pipe Hangers and Supports – Materials, Design and Manufacture, except as supplemented or modified in this Section.
3. Supports for plumbing piping shall be in accordance with the latest edition of the applicable plumbing code or local administration requirements.

B. Structural Members

1. Wherever possible, pipes shall be supported from structural members.
2. Where it is necessary to frame structural members between existing members, such supplementary members shall be provided by the Contractor.
3. Supplementary members shall be in accordance with the requirements of the Building Code and the American Institute of Steel Construction and shall be as acceptable to the Engineer.

C. Pipe Hangers

1. Pipe hangers shall be capable of supporting the pipe in operation, allowing free expansion and contraction of the piping, and preventing excessive stress on equipment.
2. Hangers shall have a means of vertical adjustment after erection.
3. Hangers shall be designed to prevent becoming disengaged by any movement of the supported pipe.
4. Hangers subject to shock, seismic disturbances, or thrust imposed by the actuation of safety valves shall include hydraulic shock suppressors.
5. Hanger rods shall be subjected to vertical loading only.

D. Hangers Subject to Lateral or Axial Movement.

1. At hanger locations where lateral or axial movement is anticipated, suitable linkage shall be provided to permit such movement.
2. Where lateral or axial pipe movement is greater than 1/2 inch, or where the hanger rod deflection from the vertical is greater than 4 degrees from the cold-to-hot position of the pipe, the hanger rod and structural attachment shall be offset in such a manner that the rod is vertical in the hot position.

E. Spring-Type Hangers

1. Spring-type pipe hangers shall be provided for piping subject to vibration or vertical expansion and contraction, such as engine exhausts and similar piping.
2. Spring-type hangers shall be sized per the manufacturer's printed recommendations and for the loading conditions encountered.
3. Variable spring supports shall be provided with means to limit misalignment, buckling, eccentric loading, or to prevent overstressing of the spring, and with means to indicate the compression of the spring.
4. Supports shall be capable of accommodating at least 4 times the maximum travel due to thermal expansion.

F. Thermal Expansion

1. Wherever expansion and contraction of piping is expected, a sufficient number of expansion loops or expansion joints shall be provided, together with the necessary rolling or sliding supports, anchors, guides, pivots, and restraints permitting the piping to expand and contract freely away from the anchored points.
2. Components shall be structurally suitable to withstand the imposed loads.

G. Heat Transmission

1. Supports, hangers, anchors, and guides shall be designed and insulated such that excessive heat will not be transmitted to the structure or to other equipment.

H. Riser Supports

1. Where practical, risers shall be supported on each floor with riser clamps and lugs, independent of the connected horizontal piping.

I. Freestanding Piping

1. Freestanding pipe connections to equipment such as chemical feeders and pumps shall be firmly attached to support frames fabricated from angles, channels, or I-beams anchored to the structure.
2. Exterior, freestanding overhead piping shall be supported on fabricated pipe stands consisting of pipe columns anchored to concrete footings, or with horizontal, welded steel angles, and U-bolts or clamps securing the pipes.

J. Materials of Construction

1. Pipe support assemblies, including framing, hardware, and anchors, shall be of steel construction, galvanized after fabrication, unless otherwise indicated.
2. Submerged supports, as well as piping, conduits, and equipment in hydraulic structures located two feet above water level, shall be supported with support assemblies, including framing, hardware, and anchors constructed of Type 316 stainless steel, unless otherwise indicated.
3. Piping in chemical and corrosive service areas shall be supported with support assemblies, including framing, hardware, and anchors constructed of Type 316 stainless steel or FRP, unless otherwise indicated.
4. Corrosive service areas are indicated in section 40 05 01– Piping General.

K. Point Loads

1. Meters, valves, heavy equipment, and other point loads on PVC, FRP, or other plastic pipes, shall be supported on both sides, according to manufacturer's recommendations, in order to avoid undue pipe stresses and failures.
2. In order to avoid point loads, the supports on PVC, FRP, or other plastic piping shall be equipped with extra wide pipe saddles or galvanized steel shields for general service and Type 316 stainless steel shields for chemical or corrosive areas.

L. Concrete Anchors

1. Unless otherwise indicated, concrete anchors for pipe supports shall be according to the following table: consult the Engineer for any anchor applications not appearing on the table.
2. Anchor embedment shall be in accordance with the requirements of Section 05 50 00– Metal Fabrications.

Pipe Support Application	Type of Concrete Anchor
New Concrete	Use embedded concrete insert anchors on a grid pattern. Use Grinnell (Anvil International), Tolco , or equal.

Existing Concrete	<p>Use non-shrink grouted anchors, expansion anchors, or epoxy anchors. Epoxy anchors are not permitted for vertical hanging applications or where sustained tension is exerted on the anchor.</p> <p>Exceptions: Expansion anchors and epoxy anchors are not permitted for pipe supports subject to vibrating loads. Epoxy anchors are not permitted where the concrete temperature is in excess of 100-degree F or higher than the limiting temperature recommended by the manufacturer.</p>
Vibratory Loads and High-Temperature Conditions	Use non-shrink grouted anchors.

M. Noise Reduction

1. In order to reduce the transmission of noise in piping systems, copper tubes in buildings and structures shall be wrapped with a 2-inch wide strip of rubber fabric or similar suitable material at each pipe support, bracket, clip, or hanger.

2.02 SUPPORT SPACING

- A. Supports for piping with the longitudinal axis in approximately a horizontal position shall be spaced to prevent excessive sag, bending, and shear stresses in the piping, with special consideration given where components such as flanges and valves impose concentrated loads.
- B. Where pipe spacing are indicated on the Drawings and are referenced to a Standard Detail, that requirement shall take preference over the general requirements of this section.
- C. Pipe support spacing shall not exceed the maximum indicated spans. Piping with grooved joint couplings, flexible joints, and bend fittings shall be balanced supported by a minimum of two pipe supports per pipe length, one at near each joint/fitting.
- D. For temperatures other than ambient temperatures or those listed, and for other piping materials or wall thicknesses, the pipe support spacings shall be modified in accordance with the pipe manufacturer's recommendations.
- E. Vertical supports shall be provided to prevent the pipe from being overstressed from the combination of loading effects.
- F. Steel Pipe
 1. Where support spacing is not indicated on the Drawings, the Contractor shall use the spacing below.
 2. Support Spacing for standard wall or heavier welded steel, stainless steel or alloy steel pipe.

Nominal Pipe Diameter, Inches	Maximum Span, ft (Water Service)	Maximum Span, ft (Gas or Vacuum Service)
1/2	6	7
3/4 and 1	8	9

1-1/4 to 2	10	12
3	12	14
4	14	15
6	16	18
8 and 10	18	20
12 and 14	20	24
16 and 18	22	26
20 and greater	24	30

G. Ductile Iron Pipe

1. Install supports for ductile iron pipe in accordance with the recommendations of the Ductile Iron Pipe Research Association (DIPRA) Design of Ductile Iron Pipe on Supports.
2. As a minimum, where support spacing is not indicated on the Drawings, the Contractor shall use the spacing indicated in the following schedule:

Nominal Pipe Diameter, inches	Support Configuration
All diameters	two supports per pipe length, with one of the two supports located at a joint

H. Copper Tube

1. Where support spacing is not indicated on the Drawings, the Contractor shall use the spacing below:

Nominal Tube Size, inches	Support Spacing, feet	
	Water Service	Vapor Service
¾ and smaller	5	5
1	6	8
1-1/2 to 2-1/2	8	10
3	10	14
4	12	16
5	13	18
6	14	20
8	16	23

I. Schedule 80 PVC and CPVC Pipe

Nominal Pipe Size, inches	100 °F and below	101 to 120 °F	121 to 140 °F
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1	5	3.5	3
1-1/2	5.5	3.5	3.5
2	6	4	3.5
3	7	4.5	4
4	7.5	5	4.5
6	9	6	5
8	9.5	6.5	5.5
10 and larger	10	7	6

J. Other Pipe Materials

1. Support spacing for pipe constructed of other materials shall be based on design temperature and in accordance with the pipe manufacturer's recommendations.

2.03 MANUFACTURED SUPPORTS

A. Stock Parts

1. Where not specifically indicated, designs that are generally accepted as exemplifying good engineering practice and using stock or production parts shall be utilized wherever possible.
2. Such parts shall be locally available, new, of best commercial quality, and designed and rated for the intended purpose.

B. Manufacturers, or Equal

1. Basic PSA, Inc.
2. Bergen-Paterson Pipe Supports Group
3. Grinnell
4. Power Piping Company
5. TOLCO (Eaton B-Line)

2.04 COATING

- A. Unless otherwise indicated, fabricated pipe supports other than stainless steel or non-ferrous supports shall be blast-cleaned after fabrication and hot-dip galvanized in accordance with ASTM A 123 - Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products and shall receive protective coatings in accordance with the requirements of Section 09 96 00– High Performance Coatings.

PART 3 -- EXECUTION

3.01 INSTALLATION

A. General

1. Pipe supports, hangers, brackets, anchors, guides, and inserts shall be installed in accordance with the manufacturer's printed instructions and per ANSI/MSS SP-58 Pipe Hangers and Supports - Materials, Design, Manufacture, Selection, Application, and Installation.
2. Embedded concrete inserts for pipe hangers and supports shall be coordinated with the formwork.

B. Appearance

1. Pipe supports and hangers shall be positioned in order to produce an orderly, neat piping system.
2. Hanger rods shall be vertical, without offsets.
3. Hangers shall be adjusted to line up groups of pipes at the proper slope for drainage and venting, as close to ceilings or roofs as possible, and without interference with other Work.

3.02 FIELD FABRICATION

A. Quality Control

1. Field fabricated pipe hangers and supports shall be fabricated and installed by experienced welders and fitters, using the best welding procedures available.
2. Hangers and supports shall be neat in appearance without sharp corners, burrs, or edges.

END OF SECTION

SECTION 40 05 19 – DUCTILE IRON PIPE (INTERIOR)

PART 1 – GENERAL

1.1 THE SUMMARY

- A. The Contractor shall provide ductile iron pipe and appurtenances, complete and in place, in accordance with the Contract Documents.

1.2 REFERENCES SPECIFICATIONS, CODES, AND STANDARDS

A. Reference Specifications

01 33 00	Submittal Procedures
03 30 00	Cast-In-Place Concrete
09 96 00	High-Performance Coatings
33 11 19	Water Mains and Appurtenances
40 05 01	Piping General
43 05 61	Gate Valves
40 05 64	Butterfly Valves
40 05 65.10	Check Valves
40 05 85	Miscellaneous Valves

B. Reference Standards:

ASTM Standards	
A 126	Gray Iron Castings for Valves, Flanges, and Pipe Fittings
C509	Elastomeric Cellular Preformed Gasket and Sealing Material
ANSI Standards	
A21.10	Gray-Iron and Ductile-Iron Fittings
A21.15	Flanged Ductile Iron Pipe with Ductile Iron or Gray Iron Threaded Flanges
B2.1	Pipe Threads (Except Dryseal)
B16.1	Cast Iron Pipe Flanges and Flanged Fittings
AWWA Standard	
C104	Cement-Mortar Lining for Ductile-Iron Pipe and Fittings for Water
C110	Ductile-Iron and Gray-Iron Fittings Pressure Pipe and Fittings
C115	Flanged Ductile Iron Pipe with Ductile Iron or Gray Iron Threaded Flanges

1.3 DEFINITIONS

- A. Where the word “pipe” or “piping” is used, it shall refer to and/or include pipe, fittings, bends, elbows, wyes, tees, reducers, and connections for pipes, piping specialties and other connections.

1.4 SUBMITTALS

- A. The Contractor shall submit Shop Drawings showing the dimensional layout, including hanger and support type and location and dimensions of all piping and equipment to be furnished before ordering. Any proposed changes in the layout of piping or equipment must be submitted with dimensioned scaled Shop Drawings. Shop Drawings shall be furnished in accordance with Section 01 33 00 – submittal procedures.
- B. Certified Letters of Compliance. The Contractor shall obtain from the Manufacturer and submit affidavits of compliance for the following:
 - 1. Ductile iron pipe in accordance with the requirements of AWWA C151 and these specifications.
 - 2. Ceramic lining of ductile iron pipe, specials, and fittings in accordance with the requirements of applicable AWWA and these specifications.
 - 3. Gasket joints for ductile iron pressure pipe and fittings in accordance with the requirements of AWWA C111 and these specifications.
 - 4. Charpy impact testing of ductile iron used in the manufacture of pipe shall be performed in accordance with AWWA C151 (The minimum corrected absorbed energy shall be 7 ft-lb at 70°F). Test report shall be signed by a professional engineer.
 - 5. Hydrostatic Shop Test signed by a professional engineer.
- C. Submit a detailed description of proposed testing procedures to be used for this project. The description shall contain the name of the person responsible for the testing work and equipment to be used. Review of the description shall not be construed as approval of any methods to be used and the Contractor shall be fully responsible for achieving the specified test results.

1.5 QUALITY ASSURANCE

- A. The manufacturers of the pipe and fittings supplied under this section shall have been in continuous business manufacturing the products supplied for the past five years.
- B. Manufacturer shall have in place a quality control and quality assurance (QA/QC) plan for all products manufactured. The QA/QC plan shall include, testing of raw materials, inspection of products prior to finishing, shop testing for pressure, strength, and dimensional checks for square, plumb, and line.
- C. Contractor shall employ a master mechanic to supervise and direct the installation of the piping system. Provide resume of master mechanic with submittal.

1.6 DELIVERY, STORAGE AND HANDLING

- A. All pipe, fittings and specialties shall be fabricated specifically for this project.

- B. All pipe, fittings, valves, and equipment shall be handled, stored, and shipped in a manner that will prevent damage. Neither chains nor cables shall be used to handle pipe.
- C. Pipe shall be shored, stored off of the ground, and protected from the weather.
- D. All open ends of pipes, valves and appurtenances shall be sealed in the manufacturer's facility prior to shipment. The pipe sections shall not be sealed by welding end caps to the pipe.

PART 2 – PRODUCTS

2.1 MATERIALS

- A. General
 - 1. Pipe supplied for this project over 2 inches in diameter shall be flanged pipe unless otherwise indicated.
 - 2. Supports and hangers shall be furnished where indicated and where required by the piping manufacturer.
 - 3. Pipe and fittings shall be drilled and tapped where indicated on the Drawings, and as required for instrumentation, valves, and gauges for testing.

2.2 DUCTILE IRON PIPE AND FITTINGS

- A. Ductile-iron pipe shall conform to ANSI/AWWA A21.15/C115, thickness Class 53, maximum working pressure of 250 psi. Flanges shall be machine tightened on the pipe, with flanges faced true to 90 degrees with the pipe axis and shall be flush with the end of pipe. Flanged Ductile Iron Pipe shall be classified by Underwriters Laboratories Inc., in accordance with ANSI/AWWA A21.15-88/C115 and/or the fabricator shall furnish a Certificate of compliance to ANSI/AWWA A21.15.88/C115 including foundry Certificates of Compliance for the Ductile Iron Pipe barrels and for the flanges. The pipe and fittings shall conform also to the following specific requirements.
- B. Ductile-iron flanged pipe shall have factory assembled, long hub, screwed-on flanges. Flanges and ductile iron flanged fittings shall conform to ANSI Standard B16.1 and AWWA/ANSI C115/A21.15.
- C. Pipe and fittings shall be cement lined with seal coat inside conforming to AWWA/ANSI C104/A21.4. Thickness of cement lining shall be at least 1/16 inch.
- D. All piping and fittings, which are to be painted shall have no outside coating of coal-tar pitch varnish.
- E. All ductile-iron pipe to be jointed with flexible couplings or flanged coupling adaptors shall have plain ends.
- F. Flanged pipe joints shall be made with full face gaskets with bulb type rings of neoprene and securely bolted meeting the requirements of ANSI/AWWA C111/A21.11.
- G. Bolts and nuts shall be of bolt steel with ANSI standard threads. Provide bolts and bolt-studs in conformance with ASTM A 307 and ANSI B1.1 with hexagonal or

square heads, coarse tread fit, threaded full length with ends chamfered or rounded. Provide hexagonal nuts with dimensions in accordance with ANSI B18.2 and coarse treads in accordance with ANSI B1.1

- H. Supports shall be as indicated or as specified herein.
- I. Ductile iron pipe and fittings shall have bosses cast on the outside wall, drilled and tapped for fittings, where indicated, or as stated elsewhere in the Specifications, or otherwise required.
- J. Pipe Flanges. All pipe flanges shall be of ductile-iron as specified above. They shall be drilled, or tapped for stud bolts, as required, with dimensions of ASTM standard for 125 pound working steam pressure. Flanges shall be faced accurately at right angles to the axis of the pipe and coated with a protective coating immediately after being faced and drilled.

2.3 FLEXIBLE COUPLINGS

- A. Flexible Couplings. Flexible couplings shall be the gasketed sleeve type, with diameters to properly fit the pipes being joined. Each coupling shall consist of a steel middle ring, two steel follower rings and two rubber-compound wedge section gaskets. Flexible couplings shall be of the type as manufactured by Rockwell Co., Dresser Industries, Baker Co. or approved equal.

2.4 FLANGED ADAPTERS

- A. Flanged Adapter Couplings. Flanged adapter couplings shall be a gasketed sleeve type, with diameter to properly fit the pipe, joining plain-end of the cut pipe to flanged fittings. Each flanged adapter shall consist of a main body flange, one follower ring and follower rubber compounded wedge section gasket and sufficient track-head steel bolts to properly compress the gaskets. Flange ring shall conform to the 125-pound ANSI standard. The couplings shall be assembled on the job in a manner to permanently tighten joints under all reasonable conditions of expansion, contraction and shifting. Flanged adapters shall be Dresser Style 128, Rockwell "Type 913", Baker "Series 604" or approved equal.

2.5 JOINTS

- A. Flanged Joints
 - 1. Flanged pipe shall have ANSI Class 125 flanges integrally cast solid and at right angles to the pipe axis, and accurately faced and drilled smooth and true. Flange bolt holes shall be back-faced or spot-faced as required by ANSI specifications.
 - 2. Bolts and nuts: Flanged joints shall be made with bolts or stud-bolts with a nut on each end. Bolts, stud-bolts, and nuts shall be made of stainless-steel ASTM A193, Grade B8M with minimum Tensile Strength of 100,000 psi. For bolts 1-3/4 inches in diameter and larger, stud-bolts shall be used. Nuts shall be made of stainless-steel ASTM A194, Grade 8M. Bolt size shall be American Standard for ANSI Class 125 flanges. Bolts and studs shall be installed with insulating Mylar sleeves with integral Mylar washers covering areas under stainless steel washers and nuts.
 - 3. Gaskets: Gasket material shall be PTFE as manufactured by W. L. Gore & Associates, Inc. or approved equal. Gaskets shall conform to Appendix A of

AWWA C115. They shall be full-face gaskets for flanged joints on 12-inch diameter and smaller pipe and shall be of the ring type for flanged joints on larger pipe.

B. Grooved-Type Joints:

1. Shall be in accordance with AWWA C606 and General Specification 15056.
2. Limit of Use: Grooved-type joints are only allowed for pipe sizes up to and including 36 inches.
3. Grooved ductile iron pipe shall be Special Thickness Class 53 for 4" - 16", Class 54 for 18", Class 55 for 20", and Class 56 for 24" - 36".

C. Mechanical and Push-On Type Joints (Buried Pipe Only):

1. Joints of buried piping shall be mechanical and push-on Type in accordance with AWWA C111.

D. Flexible Expansion Joints

1. Flexible expansion joints shall be used where indicated. Materials of construction shall include Neoprene tube reinforced with multiple plies of Nylon tire cord with a Neoprene cover. Expansion joints 24" or less shall be single sphere furnished with a set of floating galvanized steel flanges with recessed groove to interlock with rubber connector's raised face flange bead. Flange bead will be wired reinforced. Flanges will be drilled 125/150 pound ANSI. Flexible rubber expansion joints shall be rated for 225 PSIG at 170°F.
2. All connectors shall have a burst pressure of 4:1 over the rated pressure. Flexible expansion joints shall be Proco Series 240/242, General Rubber Co., or equal.
3. All flexible expansion joints shall have restraining rods to limit expansion to 10% less than the maximum rated expansion.

2.6 PIPE SLEEVES

- A. Pipe Sleeves. All pipe sleeves for use where piping extends through concrete slabs shall be of galvanized steel, unless otherwise indicated, and shall be equipped with cast or center flange water stops and with plain ends, as indicated.

2.7 RIGID CUT GROOVED COUPLINGS

- A. Rigid Coupling housing shall be ductile iron conforming to ASTM – A536, grade 65-45-12. Housing shall have alkyd phenolic primer applied in 2.5 mil thickness
- B. Gasket – Grade "E" EPDM, temperature range -30°F to +230°F. UL classified to ANSI/NSF 61 for potable water service.
- C. Bolts/Nuts – Type 316 stainless steel, oval neck track bolts and heavy hex nuts, Grade B-8M, Class 2.

2.8 PIPE HANGERS AND SUPPORTS

- A. Pipe Hangers, Clamps, and Brackets for Pipe Support. Hangers, clamps, and brackets shall be adjustable and shall be made of galvanized steel. Hangers, clamps, and brackets for copper tubing shall be copper-plated or PVC-coated. Chain strap, perforated bar, or wire hangers will not be permitted. Hangers, clamps, and brackets shall be furnished for uses in accordance with manufacturer's recommendations. Channel systems for vertical pipe support shall be Unistrut, Globe Strut, PHS Industries, or equal.
- B. Provide concrete pipe supports as indicated. At bends provide galvanized half pipe clamp and neoprene pad. Concrete shall meet the requirements of Section 03 30 00 – Cast-In-Place Concrete.

2.9 MECHANICAL CAULKING SEALS

- A. Mechanical Caulking Seals. Sleeves shall be modular, mechanical type consisting of synthetic rubber links shaped to continuously fill the annular space between the pipe and wall sleeve. Links shall be connected by 304 stainless steel bolts and nuts.

2.10 DISMANTLING JOINTS

- A. Dismantling joints used for joining and restraining flanged fittings, pumps, meters, and valves shall be provided where indicated on the drawings and shall be as specified below.
 - 1. Standard pipe sizes for 3" and larger.
 - 2. Working Pressure
 - a. 3" – 12" nominal pipe size = 175 psi
 - b. 14" and greater nominal pipe size = 150 psi
 - 3. Followers
 - a. Cast Followers (3" – 12")
 - i. Cast using Ductile Iron 65-45-12 per ASTM A536.
 - ii. Fusing bonded epoxy finish.
 - iii. Permanently marker with part number and pipe size range for proper selection.
 - iv. Integral bolt head pocket for one wrench installation.
 - 4. Sleeve Weldment
 - a. Sleeve
 - i. Material: 3 – 5" nominal pipe size(s) Carbon Steel per ASTM A513 or A53, 6" and larger nominal pipe size(s) Carbon Steel per ASTM A283C.
 - ii. Fusion bonded epoxy finish.

- iii. Larger O.D. sleeves provided with hanging ring(s) for ease of installation.
 - b. Flange
 - i. Carbon Steel per ASTM A36.
 - ii. AWWA C207 Class D 150#.
- 5. Spool Weldment
 - a. Sleeve
 - i. Material: 3 – 6” nominal pipe size(s) Carbon Steel per ASTM A513 or A53, 8” and larger nominal pipe size(s) Carbon Steel per ASTM A283C.
 - ii. Fusion bonded epoxy finish.
 - iii. Nominal sizes 18” – 24” spool weldment sleeve are expanded larger than through-bore at flange end only. All other sizes are through-bore design.
 - iv. Telescoping design allows spool weldment to travel through sleeve weldment.
 - b. Flange
 - i. Carbon Steel per ASTM A36.
 - ii. AWWA C207 Class D 150#.
- 6. Gasket
 - a. Nitrile (Buna-N) per ASTM D2000.
 - b. Compounded to resist water, oil, natural gas, acids, alkalis, most (aliphatic) hydrocarbon fluids, and many other chemicals.
 - c. Temperature range: -20°F to +180°F.
- 7. Anchor Loop
 - a. Carbon Steel per ASTM A36.
- 8. Bolts
 - a. High Strength Low Alloy (HSLA) Steel per AWWA C111/A21.11.
 - b. 5/8”-11UNC, 4.50”, Oval Neck Track Head.
 - c. Rolled threads for improved physical characteristics, greater thread accuracy, and smooth surface finish.
- 9. Resistant Rod
 - a. Carbon Steel per ASTM A193 B7.

- b. Sizes:
 - i. 3" – 5" nominal pipe size(s) = 5/8"-11UNC, 14.00", All Thread.
 - ii. 6" – 8" nominal pipe size(s) = 3/4"-10UNC, 16.00", All Thread.
 - iii. 10" – 12" nominal pipe size(s) = 7/8"-9UNC, 17.00", All Thread.
- c. Rolled threads for improved physical characteristics, greater thread accuracy, and smooth surface finish.

10. Nuts

- a. Carbon Steel per ASTM A194 Grade 2H.
- b. Sized to mating bold restraint rod.
- c. Heavy Hex Semi-Finished.

11. Washers

- a. Carbon Steel per ASTM F844.
- b. Fe/Zn coated per ASTM F1941-10.
- c. Sized to mating bolt/restraint rod.
- d. Utilized to preserve corrosion resistance of epoxy coated surfaces and increase bearing surface.

PART 3 – EXECUTION

3.1 INSTALLATION

- A. Installation of Pipe. All pipe and fittings shall be inspected before installation. In handling pipe, pipe coating shall not be damaged. All pipe and fittings shall be cleaned with clean potable water before installation, and after installation shall be flushed with water. All pipes shall be fitted to mechanical equipment in such a manner that no stress will be developed at the connections.
- B. Couplings for grooved pipe and fittings. Couplings for grooved pipe and fittings shall be installed in accordance with the manufacturer's recommendations. At locations where required and as indicated, grooved pipe or fittings shall be connected to a flanged joint with a flanged adapter in accordance with the manufacturer's recommendation.
- C. Base Elbows. Base elbows shall be installed as indicated, supported on floors, piers, or pedestals, and bolted down. Supporting concrete piers shall be anchored to floors or foundations by dowels. Bolts and nuts shall be stainless steel.
- D. Pipe Sleeves. Pipe sleeves shall be provided wherever pipe penetrates a slab or wall. The Contractor shall be responsible for the correct location of sleeves, should any pipe sleeve be omitted or located incorrectly, Contractor shall do all work necessary to patch the incorrect location, core the new location or rework the pipe to fit the cored location.

- E. Pipe Hangers and Supports. Pipe hangers and supports shall be installed in accordance with Section 40 05 07 – Hangers and Supports for Process Piping, where indicated on the Drawings or where required by pipe manufacturer or code. All piping shall be supported at intervals of not more than 10 feet (unless otherwise on the drawings), or at less spacing, by means of adjustable galvanized steel posts, stainless steel hangers, brackets, concrete piers, or structural steel supports as indicated on the drawings.
 - 1. All hangers shall be fastened to the ceilings with inserts of strength for carrying all loads imposed on them, as indicated on the drawings. Attachment to walls and concrete ceilings shall be by stainless steel expansion shields.
 - 2. All wall or floor supports shall be anchored with bolts or dowels.
- F. Flanged joints. All flanged joints shall be bolted with through-bolts. Full face gaskets 1/8-inch thick shall be installed in all flanged joints.
- G. Flexible Couplings. Flexible couplings within buildings or structures shall be installed in accordance with manufacturer's recommendations and provided with rods to limit the expansion and contraction.
- H. Cross-Connections. No plumbing fixture, equipment, device, or piping shall be installed which will provide a cross-connection or interconnection between the potable water supply and a polluted supply which will permit or make possible the backflow of sewage, polluted water, or waste into the potable water supply system.
- I. Painting: All ductile iron piping shall receive protective coating as specified in Section 09 96 00 – High Performance Coatings.
- J. Pipe Labels: Label all pipe in accordance with Section 40 05 02 – Piping Identification.

3.2 Field Quality Control

A. Testing

- 1. All equipment shall meet the following test requirements:
 - a. Tests shall be made after all piping and appurtenant equipment have been installed.
 - b. Ductile iron and piping shall be tested to the test pressures on the process pipe schedule. Piping connecting to exterior piping requiring higher test pressures shall be tested at the higher pressure. All joints shall be tested with soap and adjusted to show no leakage.
 - c. Maintain all piping Sections to be tested full of water for 24 hours prior to conducting pressure and leakage testing. Pressure shall be maintained for a period of 60 minutes. The Owner shall witness that all piping is secure, and no leaks exist.
 - d. All pipelines and equipment shall be clean and free from any obstructions or bracing used in erection and assembly and tested as they will operate in the system.

- e. All temporary piping, calibrated pressure gauges and other equipment including air needed for a complete test shall be furnished by the Contractor.
- 2. Disinfection: All process piping shall be disinfected in accordance with Section 33 05 05.50 - Pressure Pipe Testing and Disinfection.

END OF SECTION

SECTION 40 05 23 – STAINLESS STEEL PROCESS PIPE & TUBING

PART 1 -- GENERAL

1.01 THE SUMMARY

- A. The Contractor shall provide stainless steel pipe and appurtenances, complete and in place, in accordance with the Contract Documents.
- B. The requirements of Section 40 05 01 - Piping General and Section 40 05 07– Hangers and Supports for Process Piping apply to the Work of this Section.

1.02 CONTRACTOR SUBMITTALS

- A. In addition to the submittals required by Section 01 33 00– Submittal Procedures and Section 40 05 01– Piping General, provide proposed post welding cleaning method (including precleaning, descaling, chemicals to be used) or mechanical descaling method and final cleaning/passivation.
- B. Provide written certification that the pipe as supplied are in accordance with ASTM A409 or ASTM A778, if the pipes are provided, supplemental testing is not required.

1.03 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

A. Reference Specifications

01 33 00	Submittal Procedures
40 05 01	Piping General
40 05 07	Hangers and Supports for Process Piping

B. Reference Standards

American Society of Mechanical Engineers (ASME)	
ASME B16.9	Factory-Made Wrought Steel Butt-Welding Fittings
ASME B16.11	Forged Fittings, Socket-Welding and Threaded
ASME B16.5	Pipe Flanges and Flanged Fittings
ASTM International (ASTM)	
ASTM A312	Seamless and Welded Austenitic Stainless-Steel Pipe
ASTM A380	Cleaning, Descaling, and Passivation of Stainless-Steel Parts, Equipment, and Systems
ASTM A403	Wrought Austenitic Stainless Steel Piping Fittings
ASTM A409	Standard Specification for Welded Large Diameter Austenitic Steel Pipe for Corrosive or High-Temperature Service
ASTM A778	Standard Specification for Welded, Unannealed Austenitic Stainless Steel Tubular Products
ASTM A967	Standard Specification for Chemical Passivation Treatments for Stainless Steel Parts
American Water Works Association (AWWA)	
AWWA C606	Grooved and Shouldered Joints

PART 2 -- PRODUCTS

2.01 PIPE MATERIAL

- A. Unless otherwise indicated, stainless steel pipe shall be in accordance with ASTM A312 - Seamless and Welded Austenitic Stainless-Steel Pipe, Type 316L seamless, of the schedules indicated. Stainless steel pipe 12 inches in diameter and larger shall be in accordance with ASTM A409 - Welded Large Diameter Austenitic Steel Pipe for Corrosive or High-Temperature Service or ASTM A778 - Welded, Unannealed Austenitic Stainless Steel Tubular Products, Type 316L, of the schedules indicated, with welded or flanged joints. Piping less than 3 inches in nominal diameter shall have a minimum wall thickness not less than the Schedule 40S.

2.02 PIPE JOINTS

- A. Stainless steel pipe for sizes 2-1/2 inches and smaller shall have threaded ends with NPT threads made up with Teflon tape. Stainless steel pipe 3 inches and larger and where indicated shall have welded joints with socket-welding fittings, butt-welding fittings, or socket welding flanges. Stainless steel flanges shall have stainless steel bolts and nuts. Where indicated, stainless steel pipe shall have grooved ends for shouldered couplings, except that no pipe with less than Schedule 40 wall thickness shall be grooved. Where indicated, stainless steel pipe shall have plain ends for sleeve-type couplings.
- B. Threaded joints (all sizes) are not allowed for the following fluid services: sodium hydroxide, sulfuric acid, oxygen, and other fluid services indicated in pipe schedule.

2.03 FITTINGS

- A. Threaded Fittings: Forged stainless steel fittings conforming to ASME B16.11 - Forged Fittings, Socket-Welding and Threaded, Type 316.
- B. Socket-Welding Fittings: Forged stainless steel fittings conforming to ASME B16.11, Type 316.
- C. Butt-Welding Fittings: Wrought stainless steel butt-welding fittings conforming to ASTM A403 - Wrought Austenitic Stainless Steel Piping Fittings, and ASME B16.9 - Factory-Made Wrought Steel Butt-Welding Fittings, Type 316.
- D. Grooved Fittings: Wrought stainless steel grooved fittings conforming to ASTM A403 and ASME B16.9, with grooving conforming to AWWA C606 - Grooved and Shouldered Joints, Type 316.
- E. Flanged Fittings: Type 316 stainless steel flanged fittings and flanges conforming to ASME B16.5 - Pipe Flanges and Flanged Fittings.
- F. Pressure Class: Unless otherwise indicated, fittings shall be in accordance with the pressure classes called for in the Piping Schedule. Where not indicated, the fittings shall have the same pressure rating as the pipe.

2.04 CLEANING

- A. Stainless steel pipe and fittings shall be pickled at the point of manufacture, scrubbed, and washed until all discoloration is removed in accordance with ASTM A380 - Cleaning, Descaling, and Passivation of Stainless-Steel Parts, Equipment, and Systems or ASTM A967 - Standard Specification for Chemical Passivation Treatments for Stainless Steel Parts.

PART 3 -- EXECUTION

3.01 GENERAL

- A. Installation, inspection, and field testing of the pipes shall in accordance with the requirements of Section 40 05 01 - Piping General.

END OF SECTION

SECTION 40 05 31.13 – POLYVINYL CHLORIDE PROCESS PIPE

PART 1 -- GENERAL

1.01 THE SUMMARY

- A. The Contractor shall provide polyvinyl chloride (PVC) pressure pipe and appurtenances, complete and in place, in accordance with the Contract Documents.
- B. The requirements of Section 40 05 01 - Piping General and Section 40 05 07– Hangers and Supports for Process Piping apply to the Work of this Section.
- C. This Section includes PVC pressure pipe with solvent-welded, flanged, or threaded joints. PVC pipe with bell and spigot joints is included in Section 33 95 53 – Polyvinyl Chloride Pressure Piping (AWWA C900)

1.02 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

A. Reference Specifications

40 05 01	Piping General
40 05 02	Piping Identification
40 05 07	Hangers and Supports for Process Piping

B. Reference Standards

American Society of Mechanical Engineers (ASME)	
ASME B16.5	Pipe Flanges and Flanged Fittings
ASTM International (ASTM)	
ASTM D1785	Poly (Vinyl Chloride) (PVC) Plastic Pipe
ASTM D2467	Socket-Type Poly (Vinyl Chloride) (PVC) Plastic Pipe Fittings
ASTM D2564	Standard Specification for Solvent Cements for Poly(Vinyl Chloride) (PVC) Plastic Piping Systems
ASTM F1498	Taper Pipe Threads 60 Degrees for Thermoplastic Pipe and Fittings
American Water Works Association (AWWA)	
AWWA C900	Polyvinyl Chloride (PVC) Pressure Pipe, and Fabricated Fittings, 4 In. Through 60 In.
AWWA C905	Polyvinyl Chloride (PVC) Pressure Pipe and Fabricated Fittings, 14 In. Through 48 In., for Water Transmission and Distribution

PART 2 -- PRODUCTS

2.01 PIPE MATERIAL

- A. PVC pipe shall be made from new rigid unplasticized polyvinyl chloride and shall be normal impact Type 1, Grade 1, class 12454, Schedule 80, listed as compliant with NSF Standard 61, unless otherwise indicated, in accordance with ASTM D1785 –Poly (Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, and 120.

2.02 PIPE JOINTS

- A. Pipe joints shall be solvent-welded type with solvent cement and primer as recommended by the pipe manufacturer for the fluid in the pipe.
- B. Threaded joints that are necessary to match up to threaded valves or fittings shall be made up with appropriate thread sealant, either paste or tape. Pipe threads shall conform to ASTM F1498 - Taper Pipe Threads 60 Degrees for Thermoplastic Pipe and Fittings and shall be full and cleanly cut with sharp dies or molded.
- C. Flanged joints shall be made with solvent-welded PVC flanges, drilled to ASME B16.5 - Pipe Flanges and Flanged Fittings, Class 150, unless otherwise indicated.

2.03 FITTINGS

- A. Solvent Welded and Threaded Fittings: Solvent-welded and threaded fittings shall be Schedule 80 PVC fittings in accordance with ASTM D2467 - Socket-Type Poly (Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 80.
- B. Flanged Fittings: Flanged fittings shall be Schedule 80 fabricated PVC fittings with Class 150 flanges in accordance with ASME B16.5 - Pipe Flanges and Flanged Fittings, Class 150.

2.04 SOLVENT CEMENT

- A. Solvent cement shall be in accordance with ASTM D2564 and certified by the manufacturer for the service of the pipe.
- B. Potable Water Applications: Solvent cement listed by NSF for potable water applications.
- C. Manufacturer: IPS® Corporation, or equal.

PART 3 -- EXECUTION

3.01 GENERAL

- A. Installation, inspection, and field testing of the pipes shall in accordance with the requirements of Section 40 05 01 - Piping General.

END OF SECTION

SECTION 40 05 51 – COMMON REQUIREMENTS FOR PROCESS VALVES

PART 1 -- GENERAL

1.01 SUMMARY

- A. Provide valves, actuators, and appurtenances, complete and operable, as indicated in accordance with the Contract Documents.
- B. The requirements of Section 46 01 00– Equipment General Provisions, apply to the Work of this Section.
- C. The provisions of this Section shall apply to all valves and valve actuators except where otherwise indicated.
- D. Valves and actuators in particular locations may require a combination of units, sensors, limit switches, and controls, as indicated.
- E. Support
 - 1. Where a valve is to be supported by means other than the piping to which it is attached, obtain from the valve manufacturer a design for its support and foundation that satisfies the criteria in Section 46 10 00– Equipment General Provisions.
 - 2. Submit the support design, including drawings and calculations sealed by an engineer, with the Shop Drawings.
- F. Unit Responsibility
 - 1. The Contractor shall assign a single manufacturer to be responsible for the supply, coordination of design, assembly, testing, and furnishing of each valve; however, the Contractor shall be responsible to the Owner for compliance with the requirements of each valve Section.
- G. Single Manufacturer
 - 1. Where 2 or more valves of the same type and size are required, the valves shall be furnished by the same manufacturer.

1.02 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

A. Reference Specifications

46 01 00	Equipment General Provisions
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B. Reference Standards

American National Standards Institute (ANSI)	
American Water Works Association (AWWA)	
ASTM International (ASTM)	
ASTM A 48	Standard Specification for Gray Iron Castings
ASTM A 126	Standard Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings

ASTM A 216	Standard Specification for Steel Castings, Carbon, Suitable for Fusion Welding, for High-Temperature Service
ASTM A 351	Standard Specification for Castings, Austenitic, for Pressure-Containing Parts
ASTM A 395	Standard Specification for Ferritic Ductile Iron Pressure-Retaining Castings for Use at Elevated Temperatures
ASTM A 515	Standard Specification for Pressure Vessel Plates, Carbon Steel, for Intermediate- and Higher-Temperature Service
ASTM A 536	Standard Specification for Ductile Iron Castings
ASTM B 62	Standard Specification for Composition Bronze or Ounce Metal Castings
ASTM B 584	Standard Specification for Copper Alloy Sand Castings for General Applications
Manufacturers Standardization Society of the Valve and Fittings Industry (MSS)	
MSS SP-25	Standard Marking Systems for Valves, Fittings, Flanges, and Unions
NSF International (NSF)	
NSF/ANSI 61	Drinking Water System Components – Health Effects

1.03 CONTRACTOR SUBMITTALS

- A. Furnish submittals in accordance with the requirements of Section 01 33 00– Submittal Procedures.
- B. Furnish the following information on Shop Drawings:
 - 1. valve name, size, Cv factor, pressure rating, identification number (if any), and specification section number.
 - 2. complete information on the valve actuator, hydraulic power units (HPU), pneumatic air supply system including size, manufacturer, model number, limit switches, and mounting.
 - 3. cavitation limits for control valves.
 - 4. assembly drawings showing part nomenclature, materials, dimensions, weights, and relationships of valve handles, hand wheels, position indicators, limit switches, integral control systems, needle valves, and control systems.
 - 5. complete wiring diagrams and control system schematics; and,
 - 6. A valve-labeling schedule, listing the valves to be furnished with stainless steel tags, indicating in each case the valve location and the proposed wording for the label.
- C. Furnish a technical manual containing the required information for each valve, as indicated.
- D. Furnish a spare parts list, containing the required information for each valve assembly, as indicated.
- E. Factory Test Data

1. Where indicated, submit signed, dated, and certified factory test data for each valve requiring certification, before shipping the valve.
2. Furnish a certification of quality and test results for factory-applied coatings.

F. Field Test Data

1. Submit signed, dated, and certified field test data for each valve.

PART 2 -- PRODUCTS

2.01 PRODUCTS

A. General

1. Provide valves and gates of new and current manufacture.
2. Provide valves 6-inch and larger with actuators with position indicators.
3. Unless otherwise indicated, provide valve actuators in accordance with Section 40 05 57– Actuators for Process Valves and Gates.

B. Protective Coating

1. Coat the exterior surfaces of valves and the wet interior surfaces of ferrous valves of sizes 2-inch and larger in accordance with the requirements of Section 09 96 00– High-Performance Coatings.
2. The valve manufacturer shall certify in writing that the required coating has been applied and tested in the manufacturing plant prior to shipment, in accordance with the indicated requirements.
3. Do not coat the machined flange faces of valves except where such flanges are not adjoining a mating flange as shown in the Contract Documents. Apply rust inhibitor coating on machined surfaces of the flange prior to shipment.

C. Valve Labeling

1. Except when such requirement is waived by the Engineer in writing, provide a label on shut-off valves and control valves except for hose bibbs and chlorine cylinder valves.
2. Furnish a label composed of 1/16-inch plastic or stainless steel, a minimum of 2 inches by 4 inches in size, as indicated in Section 40 05 02– Piping Identification Systems, and permanently attached to the valve or on the wall adjacent to the valve as directed by the Engineer.

D. Valve Testing

1. As a minimum, unless otherwise indicated or recommended by the reference standards, test valves 3 inches in diameter and smaller in accordance with the manufacturer's standard procedure.
2. Factory-test valves 4 inches in diameter and larger as follows:
 - a. Hydrostatic Testing

- 1) Subject valve bodies to an internal hydrostatic pressure equivalent to twice the water-rated pressure of the valve.
- 2) Metallic valves rating pressures shall be based at 100 degrees F.
- 3) Plastic valves rating pressures shall be based at 73 degrees F, or at a higher temperature according to material type.
- 4) During the hydrostatic test, there shall be no visible leakage through the valve body, end joints, or shaft seals, nor shall parts of the valve be permanently deformed.
- 5) Allow test duration of at least 10 minutes, in order to allow visual examination for leakage.

b. Seat Testing

- 1) Test the valves for leaks in the closed position, with the pressure differential across the seat equal to the water rated pressure of the valve.
- 2) Provide test duration of at least 10 minutes, in order to allow visual examination for leakage.
- 3) The leakage rate shall be the more stringent of the following:
 - a) As recommended by the reference standard for that type of valve; or
 - b) Leakage past the closed valve not to exceed one fluid ounce per hour per inch diameter for metal seated valves and drop-tight for resilient seated valves.

c. Performance Testing

- 1) Shop-operate the valves from the fully-closed to the fully-open position and reverse under no-flow conditions in order to demonstrate that the valve assembly operates properly.

E. Certification

1. Prior to shipment of valves with sizes larger than 12-inches in diameter, submit certified, notarized copies of the hydrostatic factory tests, showing compliance with the applicable standards of AWWA, ANSI, or ASTM.

F. Valve Markings

1. Permanently mark valve bodies in accordance with MSS SP-25 - Standard Marking Systems for Valves, Fittings, Flanges, and Unions.

2.02 MATERIALS

A. General

1. Provide materials suitable for the intended application.
2. Provide materials in contact with potable water listed as compliant with NSF/ANSI 61.

3. Ensure that materials not indicated are of high-grade standard commercial quality, free from defects and imperfections that might affect the serviceability of the product for the purpose for which it is intended.
4. Unless otherwise indicated, provide valve and actuator bodies conforming to the following requirements:
 - a. Cast Iron: Close-grained gray cast iron, conforming to ASTM A 48 - Gray Iron Castings, Class 30, or to ASTM A 126 - Gray Iron Castings for Valves, Flanges, and Pipe Fittings
 - b. Ductile Iron: ASTM A 536 - Ductile Iron Castings, or to ASTM A 395 - Ferritic Ductile Iron Pressure-Retaining Castings for Use at Elevated Temperatures
 - c. Steel: ASTM A 216 - Steel Castings, Carbon Suitable for Fusion Welding for High-Temperature Service, or to ASTM A 515 - Pressure Vessel Plates, Carbon Steel, for Intermediate- and Higher-Temperature Service
 - d. Bronze: ASTM B 62 - Composition Bronze or Ounce Metal Castings, and valve stems not subject to dezincification shall conform to ASTM B 584 - Copper Alloy Sand Castings for General Applications. Bronze materials in contact with potable water service shall be free of lead content meeting the Lead Reduction Act.
 - e. Stainless Steel: Stainless steel valve and operator bodies and trim shall conform to ASTM A 351 - Steel Castings, Austenitic, for High-Temperature Service, Grade CF8M, or shall be Type 316 stainless steel
 - f. PVC: Polyvinyl chloride materials for valve body, flanges, and cover shall conform to Cell Classification 12454
 - g. CPVC: Chlorinated Poly Vinyl Chloride materials for valve body, flanges, and cover shall conform to Cell Classification 23447
 - h. NSF/ANSI 61: Materials shall be listed for use in contact with potable water.
 - i. Elastomeric materials used for seat, seals and O-rings shall be compatible with temperature, pressures and fluid or gas service.

2.03 VALVE CONSTRUCTION

A. Bodies

1. Provide valve bodies that are cast, molded (in the case of plastic valves), forged, or welded, of the materials indicated, and with smooth interior passages.
2. Provide wall thicknesses uniform and in agreement with the applicable standards for each type of valve, without casting defects, pinholes, and other defects that could weaken the body.
3. Perform welds on welded bodies by certified welders and ground welds smooth.
4. Provide valve ends as indicated and rated for the maximum temperature and pressure to which the valve will be subjected.

B. Valve End Connections

1. Unless otherwise indicated, valves 2-1/2 inches in diameter and smaller may be provided with threaded end connections.
2. Provide valves 3 inches in diameter and larger with flanged end connections.
3. Flanges, bolts and gaskets shall be as specified in Section 40 05 01- Piping General.

C. Bonnets

1. Connect valve bonnets to the body by clamping, screwing, or flanging.
2. Provide bonnets of the same material, temperature, and pressure rating as the body.
3. Make provisions for the stem seal with the necessary glands, packing nuts, and yokes.

D. Stems

1. Provide valve stems of the materials indicated, or, if not indicated, of the best commercially-available material for the specific service, with adjustable stem packing, O-rings, chevron V-type packing, or other suitable seal. Bronze materials in contact with potable water shall be NSF 61 approved and free of lead. Elastomeric materials shall be compatible with fluid service.
2. Where subject to dezincification, bronze valve stems shall conform to ASTM B 62.
3. Where dezincification is not a problem, bronze conforming to ASTM B 584 may be used, except that the zinc content shall not exceed 16 percent.

E. Stem Guides

1. Provide stem guides spaced with an L/R ratio not to exceed 200:1. Submit calculations for L/R ratios and guide spacing to the Engineer for review.
2. Stem guides shall have slotted holes and shall be adjustable in two directions.
3. Construct submerged stem guides from Type 316 stainless steel.

F. Internal Parts

1. Provide internal parts and valve trim as indicated for each individual valve.
2. Where not indicated, construct valve trim from Type 316 stainless steel or other material best-suited for the intended service.

G. Nuts and Bolts

1. Unless otherwise indicated, provide nuts and bolts on valve flanges and supports in accordance with the requirements of Section 05 50 00– Metal Fabrications and Section 40 05 01– Piping General.

2.04 TORQUE TUBES

- A. Submerged or buried valves with a remote gearbox and actuator shall be supplied with a torque tube to transfer torque from the actuator to the valve. Torque tubes shall be directly connected to the valve and the floor stand and gear actuator. Each torque tube and floor stand shall be sized to operate under the maximum service conditions for the valve. Unless otherwise indicated, torque tubes shall be made of schedule 40, steel pipe with epoxy coating suitable for the fluid service. Each submerged valve, torque tube, floor stand and actuator shall be pre-assembled and “matched marked” in the manufacturer’s shop to ensure proper fit when assembled in field.

2.05 EXTENSION SHAFT STEM

- A. Valves mounted in dry areas with gearbox attached to the valve and with remote actuator shall be supplied with an extension shaft stem with universal joint attached to the gear and actuator. All components shall be sized to operate under the maximum service conditions for the valve. Unless otherwise indicated, shaft stem and universal joints shall be made of carbon steel with epoxy coating suitable for the fluid service. Each valve, shaft stem, floor stand and actuator shall be pre-assembled and “matched marked” in the manufacturer’s shop to ensure proper fit when assembled in field.

2.06 VALVE ACTUATORS

- A. Valve actuators shall be as indicated and as specified in Section 40 05 57– Actuators for Process Valves and Gates

2.07 VALVE ACCESSORIES

- A. Provide valves complete with the accessories required to provide a functional system.

2.08 SPARE PARTS

- A. Furnish the required spare parts, suitably packaged and labeled with the valve name, location, and identification number.
- B. Furnish the name, address, and telephone number of the nearest distributor for the spare parts of each valve.
- C. Spare parts are intended for use by the Owner, after expiration of the correction of defects period.

2.09 MANUFACTURERS

- A. Valve manufacturers shall have a successful record of not less than 5 years in the manufacture of the indicated valves.

PART 3 -- EXECUTION

3.01 VALVE INSTALLATION AND TRIAL OPERATION

- A. General
 - 1. Install valves, actuating units, stem extensions, valve boxes, and accessories in accordance with the manufacturer's written instructions and as indicated.

2. Adequately brace gates in order to prevent warpage and bending under the intended use.
3. Firmly support valves in order to avoid undue stresses on the pipe.

B. Access

1. Install valves in a manner to provide easy access for actuation, removal, and maintenance, and to avoid interference between valve actuators and structural members, handrails, and other equipment.

C. Valve Accessories

1. Where combinations of valves, sensors, switches, and controls are indicated, properly assemble, and install such items such that systems are compatible and operating properly.
2. Clearly note the relationship between interrelated items on Shop Drawing submittals.

D. Trial Operation

1. After installation, schedule trial operation witnessed by the Engineer and the Owner representative.
2. All valves shall be cleaned thoroughly of all foreign materials and final adjustments made. The valves shall then be operated through one complete cycle from a fully closed position to a fully open position and back to a fully closed position to verify that the assembly is functional.
3. For control valves that operate in multiple operating scenarios, the Contractor shall simulate all operational scenarios including the hydraulic power units, pilot control system or pneumatic air supply system to demonstrate compliance to the specifications.
4. A field leakage test meeting the maximum allowable specified requirement shall be conducted.
5. Test certificate shall be signed by the valve manufacturer and the Contractor and shall be submitted to the Engineer.

END OF SECTION

SECTION 40 05 57 – ACTUATORS FOR PROCESS VALVES AND GATES

PART 1 -- GENERAL

1.01 THE SUMMARY

- A. Provide valve and gate actuators and appurtenances, complete and operable, as indicated in accordance with the Contract Documents.
- B. The provisions of this Section apply to valves and gates except where otherwise indicated in the Contract Documents.
- C. Unit Responsibility
 - 1. Make the valve or gate manufacturer responsible for the coordination of design, assembly, testing, and installation of actuators on the valves and gates; however, the Contractor shall be responsible to the Owner for compliance of the valves, gates, and actuators with the Contract Documents.
- D. Where 2 or more valve or gate actuators of the same type or size are required, the actuators shall be produced by the same manufacturer.
- E. The requirements of Division 26 apply to the Work of this Section.

1.02 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

A. Reference Specifications

01 33 00	Submittal Procedures
40 05 51	Common Requirements for Process Valves
40 61 00	Process Control and Enterprise Management Systems
40 61 96	Process Control Descriptions

B. Reference Standards

American National Standards Institute (ANSI)	
ANSI/ASME B 31.1	Power Piping
EN55011	Industrial, Scientific and Medical Equipment. Radio-Frequency Disturbance Characteristics
EN50082-2	Electromagnetic Compatibility - Generic Immunity Standard - Part 2 Industrial Environment
American Society of Mechanical Engineers (ASME)	
ASME BPVC SEC VIII	Boiler and Pressure Vessel Codes: Section VIII Rules for Construction of Pressure Vessel
American Water Works Association (AWWA)	
AWWA C 500	Metal-Seated Gate Valves for Water Supply Service
AWWA C504	Rubber-Seated Butterfly Valves
AWWA C541	Hydraulic and Pneumatic Cylinder and Vane-Type Actuators for Valves and Slide Gates
AWWA C 542	Electric Motor Actuators for Valves and Slide Gates

ASTM International (ASTM)	
ASTM A 105	Forging, Carbon Steel, for Piping Components
International Electrotechnical Commission (IEC)	
IEC 801.5	Surge Immunity Test
IEC 1000-4-5	Electromagnetic Compatibility Testing and Measurement Techniques – Surge Immunity Test
IEC 1000-4-8	Power Frequency Magnetic Field Immunity Test
National Fire Protection Association (NFPA)	
NFPA 70	National Electrical Code

1.03 CONTRACTOR SUBMITTALS

- A. Furnish submittals in accordance with the requirements of Section 01 33 00– Submittal Procedures and Section 40 05 51– Common Requirements of Process Valves.
- B. Submit Shop Drawing information for actuators with the valve and gate submittals as a complete package.
- C. Submit calculations showing dynamic seating and unseating torques versus the output torque of the actuator.

PART 2 -- PRODUCTS

2.01 GENERAL

- A. Unless otherwise indicated, provide shut-off and throttling valves and externally actuated valves and gates with manual or power actuators.
- B. Provide actuators complete and operable with mounting hardware, motors, gears, controls, wiring, solenoids, hand wheels, levers, chains, and extensions, as applicable.
- C. Provide actuators with torque ratings equal to or greater than required for valve seating and dynamic torques, whichever is greater, and capable of holding the valve in any intermediate position between fully-open and fully-closed without creeping or fluttering.
- D. Actuator torque ratings for butterfly valves shall be determined in accordance with AWWA C504 - Rubber-Seated Butterfly Valves.
- E. Identify wires of motor-driven actuators by unique numbers.
- F. Manufacturers
 - 1. Where indicated, certain valves and gates may be provided with actuators manufactured by the valve or gate manufacturer.
 - 2. Where actuators are furnished by different manufacturers, coordinate the selection to result in the fewest number of manufacturers possible.
- G. Materials
 - 1. Provide actuators of current models, of the best commercial quality materials, and liberally sized for the required torque.

2. Provide materials suitable for the environment in which the valve or gate is to be installed.

H. Actuator Mounting and Position Indicators

1. Securely mount actuators by means of brackets or hardware specially designed and sized for this purpose and of ample strength.
2. Cast the word "OPEN" on each valve or actuator, with an arrow indicating the direction to open in the counter-clockwise direction.
3. Equip gear and power actuators with position indicators.
4. Where possible, locate manual actuators between 48 and 60 inches above the floor or the permanent working platform.

I. Standards

1. Unless otherwise indicated and where applicable, provide actuators in accordance with AWWA C 542 - Electric Motor Actuators for Valves and Slide Gates.

J. Functionality

1. Coordinate electric, pneumatic, and hydraulic actuators with the power requirements of Division 26 – Electrical, and instrumentation equipment as indicated in Section 40 61 00– Process Control and Enterprise Management Systems.

K. Provide fasteners in accordance with the requirements of Section 05 50 00 – Metal Fabrications.

L. Provide coatings in accordance with the requirements of Section 09 96 00– High-Performance Coatings.

2.02 MANUAL ACTUATORS

A. General

1. Unless otherwise indicated, provide valves and gates with manual actuators.
2. Provide valves in sizes up to and including 4 inches with direct-acting lever or hand wheel actuators of the manufacturer's best standard design.
3. Provide valves and gates larger than 4-inch with gear-assisted manual actuators, with an operating pull of maximum 60 pounds on the rim of the hand wheel.
4. Provide buried and submerged gear-assisted valves, gates, gear-assisted valves for pressures higher than 250 psig, valves 30 inches in diameter and larger, and where indicated, with worm gear actuators, hermetically-sealed water-tight and grease-packed.
5. Valves 6-inch to 24-inch diameter may be provided with traveling-nut actuators, worm gear actuators, spur or bevel gear actuators, as appropriate for each valve.

B. Buried Valves

1. Unless otherwise indicated, provide buried valves with extension stems to grade, with square nuts or floor stands, position indicators, and cast-iron or steel pipe extensions with valve boxes, covers, and operating keys.
2. Where indicated, provide buried valves in cast-iron, concrete, or similar valve boxes with covers of ample size in order to allow operation of the valve actuators.
3. Permanently label the valve box covers as required by the local Utility Company or the Engineer.
4. Provide wrench-nuts in compliance with AWWA C 500 - Metal-Seated Gate Valves for Water Supply Service.

C. Floor Boxes

1. Provide hot-dipped galvanized cast iron or steel floor boxes and covers to fit the slab thickness, for operating nuts in or below concrete slabs.
2. For operating nuts in the concrete slab, provide a bronze-bushed cover.

D. Tee Wrenches

1. Furnish buried valves with floor boxes with 2 operating keys or one key per 10 valves, whichever is greater.
2. Size the tee wrenches such that the tee handle will be 2 to 4 feet above ground, and to fit the operating nuts.

E. Manual Worm Gear Actuator

1. Provide an actuator consisting of a single- or double-reduction gear unit contained in a weatherproof cast iron or steel body with cover, and a minimum 12-inch diameter handwheel.
2. Provide the actuator to be capable of a 90-degree rotation and equip the actuator with travel stops capable of limiting the valve opening and closing.
3. Provide the actuator with spur or helical gears and worm gearing.
4. Provide a self-locking gear ratio in order to prevent "back-driving."
5. Construct the spur or helical gears of hardened alloy steel, and the worm gear of alloy bronze.
6. Construct the worm gear shaft and the hand wheel shaft from 17-4 PH or similar stainless steel.
7. Accurately cut gearing with hobbing machines.
8. Use ball or roller bearings throughout.
9. Provide the output shaft end with a spline in order to allow adjustable alignment.
10. Actuator output gear changes shall be mechanically possible by simply changing the exposed or helical gearset ratio without further disassembly of the actuator.

11. Design gearing for a 100 percent overload.
 12. The entire gear assembly shall be sealed weatherproof.
- F. Design and rate buried gear actuators for buried service, provide with a stainless-steel input shaft, and double-seal on shaft and top cap.
- G. Traveling-Nut Actuator
1. Provide the actuator with a traveling-nut and screw (Scotch yoke), contained in a weatherproof cast iron or steel housing with a spur gear and a minimum 12-inch diameter hand wheel.
 2. The screw shall run in 2 end bearings and provide a self-locking actuator in order to maintain the valve position under any flow condition.
 3. Construct the screw and gear from hardened alloy steel or stainless steel, and the construct the nut and bushings from alloy bronze.
 4. The bearings and gear shall be grease-lubricated by means of nipples.
 5. Design gearing for a 100 percent overload.

2.03 ELECTRIC MOTOR ACTUATORS

A. General

1. Equipment Requirements

- a. Where electric motor actuators are indicated, attach an electric motor-actuated valve control unit to the actuating mechanism housing by means of a flanged motor adapter piece.

2. Gearing

- a. Provide the motor actuator with the motor, reduction gearing, reversing starter, torque switches, and limit switches in a weather-proof NEMA 4 assembly.
- b. Provide a single- or double-reduction unit, consisting of spur or helical gears and worm gearing.
- c. Construct the spur or helical gears of hardened alloy steel, and the worm gear of alloy bronze.
- d. Accurately cut gearing with hobbing machines.
- e. Power gearing shall be grease- or oil-lubricated in a sealed housing.
- f. Use ball or roller bearings throughout.
- g. Actuator output speed changes shall be mechanically possible by simply removing the motor and changing the exposed or helical gearset ratio without further disassembly of the actuator.

3. Starting Device

- a. Except for modulating valves, design the unit such that a hammer blow is imparted to the stem nut when opening a closed valve or closing an open valve.
- b. The device shall allow free movement at the stem nut before imparting the hammer blow.
- c. The actuator motor shall attain full speed before the stem load is encountered.

4. Switches

a. Mechanical Type Switches

- 1) Provide limit switches of the gear open-type, actuated by a cam with 4 contacts to each cam or gear train.
- 2) The torque switch shall be activated by a mechanical torque, developed in the seating of valve, or by an obstruction met in the opening and closing of the valve.
- 3) Provide an adjustable torque setting, functioning without the use of auxiliary devices or relays.
- 4) Provide position limit switches and associated gearing as an integral part of the valve actuator.
- 5) In order to provide the best possible accuracy and repeatability, provide limit switch gearing of the "counting" intermittent type, constructed of stainless steel, grease-lubricated, and enclosed in its own gear case in order to prevent dirt and foreign matter from entering the gear train.
- 6) Provide valve actuators with mechanical type switches as manufactured by **Limitorque, Rotork, EIM, Auma Actuators, Inc.**, or equal.

b. Electronic-Type Switches

- 1) Limit switches or valve position shall be sensed by a 15-bit, optical, absolute position encoder.
- 2) The open and closed positions shall be stored in a permanent, non-volatile memory.
- 3) The encoder shall measure valve position continuously, including both motor and hand wheel operation, with or without use of battery.
- 4) Provide an electronic torque sensor.
- 5) Provide an adjustable torque limit, from 40 to 100 percent of rating in one-percent increments.
- 6) The motor shall be de-energized if the torque limit is exceeded.
- 7) Provide a boost function in order to prevent torque-trip during initial valve unseating, and a "jammed valve" protection feature with automatic retry sequence in order to de-energize the motor if no movement occurs.

- 8) Provide valve actuators with electronic type switches as manufactured by **Limiterorque, Rotork or Auma Actuators, Inc.**
 - c. The actuator shall be wired in accordance with the schematic diagram.
 - d. Connect wiring for external connections to marked terminals.
 - e. Provide one 1-inch and one 1-1/4-inch conduit connection in the enclosing case.
 - f. Mount a calibration tag near each switch, correlating the dial setting to the unit output torque.
 - g. Switches shall not be subject to breakage or slippages due to over-travel.
 - h. Do not use traveling-nuts, cams, or microswitch tripping mechanisms.
 - i. Provide limit switches of the heavy-duty, open contact type, with rotary wiping action.
- 5. Handwheel Operation
 - a. Provide a permanently attached handwheel for emergency manual operation.
 - b. The handwheel shall not rotate during electrical operation.
 - c. The maximum torque required on the handwheel under the most adverse conditions shall not exceed 60 lb-ft, and the maximum force required on the rim of the handwheel shall not exceed 60 lb.
 - d. Cast or permanently affix an arrow and either the word "OPEN" or "CLOSE" on the handwheel in order to indicate the appropriate direction to turn the handwheel.
 - e. Provide a clutch lever to put the actuator into handwheel operation.
 - f. Provide chain activator handwheels for valves with electric motor actuators having stems more than 7 feet above the floor.
 - g. Provide the clutch lever with a cable secured to the chain in order to allow disengagement for manual operation.
- 6. Motor
 - a. Provide a motor of the totally enclosed, non-ventilated, high-starting torque, low-starting current type, for full-voltage starting.
 - b. The motor shall be suitable for operation on 480 volt, 3 phase, 60 Hz current, with Class F insulation and a motor frame with dimensions in accordance with the latest revised NEMA MG Standards.
 - c. The observed temperature rise by thermometer shall not exceed 55 degrees C above an ambient temperature of 40 degrees C, when operating continuously for 15 minutes under full-rated load.

- d. With a line voltage ranging between 10 percent above to 10 percent below the rated voltage, the motor shall develop full-rated torque continuously for 15 minutes without causing the thermal contact protective devices imbedded in the motor windings to trip or the starter overloads to drop out.
- e. Provide bearings of the ball type and provide thrust bearings where necessary.
- f. Provide the bearings with suitable seals in order to confine the lubricant and to prevent the entrance of dirt and dust.
- g. Provide watertight motor conduit connections.
- h. Motor construction shall incorporate the use of stator and rotor as independent components from the valve operation such that the failure of either item shall not require actuator disassembly or gearing replacement.
- i. Provide two Class B thermal contacts or solid-state thermistors embedded within the motor windings in order to protect against over-temperature damage.
- j. Provide the motor with a space heater suitable for operation on a 120-volt, single-phase, 60-Hz circuit, unless the entire actuator is of a hermetically sealed, non-breathing design with a separately sealed terminal compartment which prevents moisture intrusion.
- k. Provide each electric motor actuator with a local disconnect switch or circuit breaker in order to isolate power from the motor and controller during maintenance activities.

7. Controls

- a. Refer to the Instrumentation Drawings for the number of networks required and for valve assignments.
- b. Communications Network
 - 1) The field units shall be controlled by a 2-wire network that connects the actuators in a loop fashion through the use of RS-485 signals.
- c. Field Unit
 - 1) Enclose a field unit within each actuator.
 - 2) Status lights shall be red for "OPEN" and green for "CLOSED."

8. Open/Close Operating Speed

- a. Unless otherwise indicated, electric actuators shall provide a full-close-to-full-open or full-open-to-full-close operating time range from 30 to 55seconds.

9. Elevated Valves

- a. For valves with electric motor actuators where the valve centerline is located at a height greater than 6 feet above the floor, provide a remote actuator control station at a location no higher than 4 feet above the floor.

- b. Provide conduit and wiring between the actuator controls and the valve actuator for these applications.
- c. Wall-mount the actuator controls beneath the valve at a location approved by the Engineer.

B. Electric Motor Actuators (AC Reversing Control Type)

1. General

- a. Where indicated, electric motor actuators shall be the AC reversing type complete with local control station with OPEN/CLOSE and AUTO/REMOTE selector switches local control station

2. Actuator Appurtenances

- a. Provide the actuator for each valve with: OPEN and CLOSE status lights; OPEN, CLOSE, and LOCKOUT/STOP push buttons; and other indicated devices.

3. Starter

- a. Provide a suitably sized amperage-rated reversing starter with its coils rated for operation on 480-volt, 3-phase, 60-Hz current.
- b. Provide a control power transformer in order to provide a 120-volt source, unless otherwise indicated.
- c. Equip the starter with 3 overload relays of the automatic reset type and wire the control circuit as indicated.
- d. The integral weatherproof compartment shall contain a suitably sized 120-volt AC, single-phase, 60-Hz space heater in order to prevent moisture condensation on electrical components.
- e. Provide a local power disconnect switch and a close-coupled, padlockable switch with each actuator.

4. Local Control Station

- a. Provide each actuator with a local control station along with the valve actuator assembly.
- b. The station shall include OPEN, CLOSE, and STOP push buttons, and a LOCAL/REMOTE selector switch.
- c. Where indicated on the Instrumentation Drawings, provide a 2-wire control system as indicated above.
- d. The control system shall allow communications to the PLC via a **Modbus RS-485** protocol over a twisted shielded-pair cable in order to monitor and control the valve as indicated above and in Section 40 61 96 – Process Control Descriptions.

- e. The local control station and local power disconnect may be provided as an integral part of the actuator, or as otherwise indicated or required in order to permit operation by a person at floor elevation and within sight of the valve actuator.
5. Electric Motor Actuators (AC Reversing Control Type) Manufacturer, or Equal
- a. Auma Actuators, Inc.
 - b. Limitorque Corp
 - c. Rotork
- C. Electric Motor Actuators (AC Modulating Control Type)
1. General
- a. Where indicated, modulating electric motor actuators shall be of the AC-modulating type, provided complete with a local control station with power disconnect switch or circuit breaker, LOCAL/REMOTE switch, non-latching OPEN/CLOSE pushbuttons, and OPEN/CLOSE status lights
2. Actuator Appurtenances
- a. Provide the actuator for each valve with a padlock able disconnect switch; OPEN and CLOSED status lights; OPEN, CLOSE, and LOCKOUT/STOP pushbuttons; a LOCAL/REMOTE selector switch; and other indicated devices.
3. Control Module
- a. Provide a control module of the electronic solid-state AC type, with control outputs for positioning the valve via 4 to 20 ma input signals.
4. Starter
- a. The actuator shall control a solid-state reversing starter designed for minimum susceptibility to power line surges and spikes.
 - b. The solid-state starter and control module shall be rated for continuous modulating applications.
 - c. The power supply shall be 480-volt, 3-phase, 60-Hz.
 - d. Provide a disconnect switch with each actuator.
5. Construction
- a. The control unit shall be microprocessor-based and shall contain an analog/digital converter, separate input-output switches, non-volatile random-access memory for storage of calibration parameters, and push-button calibration elements for field setup.
 - b. Potentiometer adjustments shall contain a PID control function internally.

- c. The controller shall contain as a standard feature a loss-of-command signal protection selectable to lock in last or lock in pre-set valve position and a valve position output signal in 4 to 20 mA
 - d. As an alternative to the construction requirement, provide a motor capable of modulating at a rate of 200 starts per hour at the 50-percent to 85-percent travel range of the valve.
 - e. The system shall allow the control of the open, close, or percent open function when the LOCAL/REMOTE switch is in the REMOTE position.
 - f. Provide each actuator with a frequency shut-down system, which when pre-programmed shall function as directed upon receipt of an ESD signal.
6. Electric Motor Actuators (AC Modulating Control Type) Manufacturer, or Equal
- a. Limitorque
 - b. Rotork
 - c. Auma Actuators, Inc
- D. Electric Motor Actuators (DC Modulating Control Type)
- 1. Equipment Requirements
 - a. Where indicated, provide electric motor actuators of the DC modulating control type, and attach to the actuating mechanism housing.
 - 2. Actuator Assembly
 - a. The assembly shall include a DC motor, reduction gearing, a control unit, limit-switches, and required accessories, within one enclosure.
 - 3. Control Unit
 - a. Provide an electric motor-operated control unit suited for an input power supply of 90 to 140 volts, 60 Hz AC, and to operate satisfactorily when input power is within those limits.
 - b. Power will be supplied at 120 volts, single-phase, 60 Hz AC.
 - c. Provide a control unit suited to receive an input set-point signal from an external source of 4 to 20 ma DC with properly selected calibrating resistor.
 - 4. Control Panel
 - a. Provide each actuator with a separate local control panel for attachment to the valve actuator assembly.
 - b. Provide the panel with an OPEN/CLOSE/AUTO/HOLD selector switch and suitable for indoor or outdoor installation, as required.
 - 5. Electric Motor Actuators (DC Modulating Control Type) Manufacturer, or Equal
 - a. EIM, Futronic-III

- b. Limitorque Corp., Modutronic-10
- E. 120 V Quarter-Turn and Multi-Turn Electric Valve Operators (6-Inches and Smaller)
- 1. Provide 120-volt, single-phase, motor-operated valve operators suitable for use with quarter-turn ball valves, multi-turn diaphragm valves, and multi-turn globe valves.
 - 2. Provide operators with the following characteristics and features:
 - a. reversing capacitor-start motor rated for operation on 120 VAC, 60 Hz, single-phase.
 - b. output torque as required for valve application and pressure differential.
 - c. integral motor overload protection, with auto-reset.
 - d. permanently-lubricated gear train.
 - e. OPEN/CLOSE Control
 - 1) For OPEN/CLOSE control, provide 4 single-pole, double-throw cam-actuated limit switches (2 OPEN, 2 CLOSED);
 - 2) Use one set of limit switches for both motor control and local indication.
 - 3) Make the other set available for connection to remote monitoring.
 - 4) Provide adjustable limit switch contacts rated for not less than 5 amps at 120 VAC.
 - f. Local Control Station: OPEN/CLOSE
 - 1) corrosion-resistant, NEMA 4X, for mounting near valve actuator.
 - 2) Provide 2-position selector switch for LOCAL/REMOTE selection and 2 pushbuttons, OPEN and CLOSE.
 - 3) Provide OPEN and CLOSE indicating lights operating at 120 VAC for connection to valve control limit switches;
 - g. Modulating Control
 - 1) For modulating control, provide an electronic positioner and feedback potentiometer.
 - 2) The positioner shall use a 4 to 20 ma signal to adjust the valve opening.
 - 3) Feedback potentiometer shall be 0 to 1000 ohms.
 - h. Local Control Station Modulating
 - 1) corrosion resistant, NEMA 4X, for mounting near valve actuator.

- 2) Provide 2-position selector switch for LOCAL/REMOTE selection, one OPEN and one CLOSE push button, a resistance-to-current converter with 4 to 20 ma output, and a zero to 100 percent electronic valve position indicator; and,
- i. Disconnect Switch
 - 1) Provide a local power disconnect switch, NEMA 4X, for disconnecting the 120 VAC power to the valve and,
 - 2) Install the disconnect in the field within sight of the valve actuator, in accordance with the requirements of NPFA 70.
3. Refer to the Drawings for the control diagram wiring interface.
4. Two-wire control systems are not required for this actuator.
5. 120 V Quarter-Turn and Multi-Turn Electric Valve Operators (6-Inches and Smaller) Manufacturer, or Equal
 - a. RCS
 - b. Asahi/America, Quarter Master

PART 3 -- EXECUTION

3.01 SERVICES OF MANUFACTURER

A. Field Adjustments

1. The adjustment of actuator controls and limit switches in the field for the required function shall be performed by field representatives of the manufacturers of valves or gates with pneumatic, hydraulic, or electric actuators.

3.02 INSTALLATION

- A. Install valve and gate actuators and accessories in accordance with the requirements of Section 40 05 51– Common Requirements for Process Valves.
- B. Locate the actuators to be readily accessible for operation and maintenance without obstructing walkways.
- C. Do not mount actuators where shock or vibrations will impair their operation, and do not attach the support systems to handrails, process piping, or mechanical equipment.

END OF SECTION

SECTION 40 05 61 – GATE VALVES

PART 1 -- GENERAL

1.01 SUMMARY

- A. The Contractor shall provide gate valves and appurtenances, complete and operable, in accordance with the Contract Documents.
- B. The requirements of Section 40 05 51 – Common Requirements for Process Valves apply to this Section.
- C. The requirements of Section 40 05 57 – Actuators for Process Valves and Gates apply to this Section.

1.02 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

A. Reference Specifications

09 96 00	High-Performance Coatings
40 05 51	Common Requirements for Process Valves
40 05 57	Actuators for Process Valves and Gates

B. Reference Standards

American Water Works Association (AWWA)	
AWWA C500	Metal-Seated Gate Valves for Water Supply Service
AWWA C509	Resilient-Seated Gate Valves for Water and Sewerage Systems
ASTM International (ASTM)	
ASTM A126	Gray Iron Castings for Valves, Flanges, and Pipe Fittings
ASTM A395	Ferritic Ductile Iron Pressure-Retaining Castings for Use at Elevated Temperatures
ASTM A536	Ductile Iron Castings
ASTM B62	Composition Bronze or Ounce Metal Castings
ASTM B371	Copper-Zinc-Silicon Alloy Rod

1.03 CONTRACTOR SUBMITTALS

- A. Furnish submittals in accordance with Section 40 05 51 – Common Requirements for Process Valves.

PART 2 -- PRODUCTS

2.01 GENERAL

- A. Buried valves shall be of the inside screw, non-rising stem type. The valve actuators shall be as indicated, with counter-clockwise opening stems, in accordance with Section 40 05 57 – Actuators for Process Valves and Gates.
- B. Gate valves 18-inches and larger shall be provided with a bypass line and isolation valve.

2.02 RESILIENT-SEATED GATE VALVES

- A. General: Resilient-seated gate valves may be provided in lieu of metal-seated double-disc or solid-disc gate valves, at the discretion of the Engineer.
- B. For 250-psig applications, consult the valve manufacturer and revise this Section accordingly.
- C. Construction: Resilient-seated gate valves shall conform to AWWA C509 - Resilient-Seated Gate Valves for Water and Sewerage Systems. The valves shall be suitable for a minimum design working water pressure of 150 psig, with flanged, bell and spigot, or mechanical joint ends. The valve body, bonnet, and disc shall be of cast iron or ductile iron and the disc or body shall be rubber-coated. Body and bonnet wall thickness shall be equal to or greater than the minimum wall thickness as listed in Table 1 of AWWA C509. The stem, stem nuts, glands, and bushings shall be bronze, with the stem seal per AWWA C509.
- D. Pressure Ratings:
 - 1. AWWA C509 valves that are 3, 4, 6, 8, and 12 inches in size shall be rated for 200 psig minimum design working water pressure, and 16-, 20-, 24-, and 30-inch valves shall be rated for 150 psig minimum design working water pressure.
 - 2. AWWA C515 valves 3- through 36-inch with outside screw-and-yoke (OS&Y) rising stem and 3- through 16-inch for non-rising-stem (NRS), shall be rated for 200 psig minimum design working water pressure.
- E. Protective Coating: Valves shall be factory coated in accordance with Section 09 96 00– High-Performance Coatings. The Contractor shall submit a test report from a coating inspector that the coating is holiday-free. The Contractor shall be aware that it may retain the services of a third-party coating applicator to achieve the holiday-free requirement.
- F. Actuators: Unless otherwise indicated, resilient-seated gate valves shall have manual actuators in accordance with Section 40 05 57 – Actuators for Process Valves and Gates.
- G. Manufacturers, or Equal
 - 1. Mueller Company
 - 2. McWane (Clow, Kennedy, M & H)
 - 3. J&S Valve

PART 3 -- EXECUTION

3.01 GENERAL

- A. Gate valves shall be installed in accordance with the provisions of Section 40 05 51 – Common Requirements for Process Valves. Care shall be taken that valves in plastic lines are well supported at each end of the valve.

END OF SECTION

SECTION 40 05 64 – BUTTERFLY VALVE

PART 1 -- GENERAL

1.01 SUMMARY

- A. The Contractor shall provide butterfly valves and appurtenances, complete and operable, in accordance with the Contract Documents.
- B. The requirements of Section 46 01 00 – Equipment General Provisions apply to this Section.
- C. The requirements of Section 40 05 51 – Common Requirements for Process Valves apply to this Section.
- D. The requirements of Section 40 05 57 – Actuators for Process Valves and Gates apply to this Section.

1.02 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

A. Reference Specifications

01 33 00	Submittal Procedures
09 96 00	High-Performance Coatings
40 05 51	Common Requirements for Process Valves
40 05 57	Actuators for Process Valves and Gates
46 01 00	Equipment General Provisions

B. Reference Standards

American National Standards Institute (ANSI)	
ANSI B 16.1	Gray Iron Pipe Flanges and Flanged Fittings Classes 25, 125, and 250
American Petroleum Institute (API)	
API 598	Valve Inspection and Testing
API 609	Butterfly Valves: Double-flanged, Lug- and Wafer-type, and Butt-welding Ends
American Society of Mechanical Engineers (ASME)	
ASME B31.1	Power Piping
ASME B31.3	Process Piping
American Water Works Association (AWWA)	
AWWA C504	Standard for Rubber-Seated Butterfly Valves
AWWA C541	Hydraulic and Pneumatic Cylinder and Vane-Type Actuators for Valves and Slide Gates
ASTM International (ASTM)	
ASTM A 36	Standard Specification for Carbon Structural Steel
ASTM A 48	Standard Specification for Gray Iron Castings
ASTM A 126	Standard Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings

ASTM A 216	Steel Castings, Carbon Suitable for Fusion Welding for High-Temperature Service
ASTM A 240	Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications
ASTM A 276	Standard Specification for Stainless Steel Bars and Shapes
ASTM A 351	Steel Castings, Austenitic, for High-Temperature Service
ASTM A 436	Standard Specification for Austenitic Gray Iron Castings
ASTM A 439	Standard Specification for Austenitic Ductile Iron Castings
ASTM A 515	Pressure Vessel Plates, Carbon Steel, for Intermediate-and Higher-Temperature Service
ASTM A 536	Standard Specification for Ductile Iron Castings
ASTM A 564	Standard Specification for Hot-Rolled and Cold-Finished Age-Hardening Stainless-Steel Bars and Shapes
ASTM A 743	Castings, Iron-Chromium, Iron-Chromium-Nickel, and Nickel-Base Corrosion - Resistant for General Application
ASTM UNS S31803 SS	Duplex Stainless Steel

1.03 CONTRACTOR SUBMITTALS

- A. Furnish submittals in accordance with Section 40 05 51 – Common Requirements for Process Valves.
- B. Shop Drawings
 - 1. Complete Shop Drawings of butterfly valves and actuators.
 - 2. Drawings showing valve port diameter complete with dimensions, part numbers, and materials of construction.
 - 3. Dynamic seating and unseating torque for motor actuated valves.
 - 4. Certified statement of proof-of-design tests from the valve manufacturer. Valve manufacturer shall state that the valves proposed for this project will be manufactured with identical basic type of seat design and materials of construction to the prototype evaluated under the proof of design testing.
 - 5. Manufacturer's certification that the valve complies with applicable provisions of AWWA C504 – Rubber-Seated Butterfly Valves.

1.04 QUALITY ASSURANCE

- A. Valves shall be subjected to performance, leakage, and hydrostatic tests in accordance with procedures and acceptance criteria established by AWWA C504.

PART 2 -- PRODUCTS

2.01 RUBBER SEATED BUTTERFLY VALVES 25 TO 150 PSI (AWWA)

- A. General: Butterfly valves for steady-state water working pressures and steady-state differential pressure up to 150 psi and for freshwater service having a pH range from 6 to 10 and temperature range from 33 to 125 degrees F shall conform to AWWA C504 and be as indicated. Valves subjected to steady state working pressures and steady state differential pressures from 25 to 150 psi in sizes 3-inches through 24-inches shall be rated for Class 150B with actuator sized for Class 150B. Valves 30 inches through 72-inches shall be of the class indicated. Valves larger than 72-inches shall be of the class indicated, designed in accordance with the intent of AWWA C504. If the operating conditions such as flow, velocity, and differential pressures are not indicated, the valve body and shaft shall be sized for the pressure class rating of the valve.
- B. Valves shall be of the body type, pressure class, end joint, and actuator indicated.
- C. Construction: Unless otherwise indicated, materials of construction shall be in accordance with AWWA C504, suitable for the service. Seats shall be positively clamped or bonded into the disc or body of the valve, but cartridge-type seats that rely on a high coefficient of friction for retention shall not be acceptable. Seat material shall be guaranteed to last for at least 75 percent of the number of cycles in the AWWA C504 proof-of-design test without premature damage.

Description	Material Standards
Valve bodies	Gray iron, ASTM A 48, Class 40
End flanges	Same material as valve bodies
Valve shafts	Stainless steel ASTM A 240 or A 276, Type 316
Valve discs	Same material as valve bodies.
Rubber seats	New natural or synthetic rubber
Seat mating surfaces	Stainless steel, ASTM A 240 or A 276, Type 316
Clamps and retaining rings	Type 316 retaining rings and cap screws.
Valve bearings	Self lubricating materials per AWWA C504
Shaft seals	Resilient non-metallic materials suitable for service
Painting and coating	Refer to Section 09 96 00 – High-Performance Coatings

D. Manual Actuators:

1. Unless otherwise indicated, manually-actuated butterfly valves shall be equipped with a handwheel and 2-inch square actuating nut and position indicator. Screw-type (traveling nut) actuators will not be permitted for valves 30-inches in diameter and larger.
2. Manually actuated butterfly valves located in a trench shall be equipped with a yoke-style extension stem and floor stand with a handwheel and position indicator. Extension stems shall be set to allow handwheel access 3-feet above floor grating sections.

E. Electric Actuators: Electric actuators shall meet the requirements of AWWA C541. Electric actuators in open and close service shall be rated to produce output torque of at least 1.5 times the required valve maximum seating or maximum dynamic torque, whichever is greater. For valves in modulating service with dynamic torque exceeding the seating torque, the rated output torque of the actuator shall be twice the dynamic torque required by the valve. Actuator rated torque is defined as pullout torque rated at 10 percent below the rated voltage of the motor. The torque switch shall be field set at no greater than 60 percent and 50 percent of the maximum actuator rated torque for open/close service and modulating service, respectively. After plant startup, the manufacturer shall prepare a certification including a torque curve to demonstrate that the torque requirements have been met.

F. Manufacturers, or Equal

1. DeZURIK Water Controls, Corporation
2. Kennedy Valve
3. M & H Valve Company
4. Mueller Company
5. Henry Pratt Company

2.02 RUBBER SEATED BUTTERFLY VALVES, 250 PSI SERVICE (AWWA)

A. General: Butterfly valves for steady-state water working pressures and steady-state differential pressure up to 250 psi and for freshwater service having a pH range from 6 to 10 and temperature range from 33 to 125 degrees F shall conform to AWWA C504. Valves shall be designed and manufactured in accordance with the intent of AWWA C504 except valves shall be suitable for 250 psi service and as indicated herein.

B. Valves shall be of the body type, pressure class, end joint, and actuator indicated.

C. One prototype for each size of valve to be provided shall be subjected to proof-of-design tests in accordance with the procedures established by AWWA C504. Results of proof-of-design tests and certification by a company officer shall be submitted to the Engineer with the Shop Drawings.

D. Construction: Unless otherwise indicated, materials of construction shall be in accordance with AWWA C504, suitable for the service. The seats shall be positively clamped or bonded into the disc or body of the valve, but cartridge-type seats that rely on a high coefficient of friction for retention shall not be acceptable. Seat material shall be guaranteed to last for at least 75 percent of the number of cycles in the AWWA C504 proof-of-design test without premature damage.

Designation	Materials Standards
Valve Bodies	Gray iron, ASTM A 48, Class 40 Ductile iron, ASTM A 536, grade 65-45-12 or 70-50-05 Alloy gray iron, ASTM A 436, Type1 or 2
End flanges	Same material as valve bodies
Valve shafts	Stainless steel ASTM A 240 or A 276, Type 316
Valve discs	Same material as valve bodies.

Designation	Materials Standards
Rubber seats	New natural or synthetic rubber
Seat mating surfaces	Stainless steel, ASTM A 240 or A 276, Type 316
Clamps and retaining rings	Type 316 retaining rings and cap screws.
Valve bearings	Self lubricating materials per AWWA C504
Shaft seals	Resilient non-metallic materials suitable for service
Painting and coating	Refer to Section 09 96 00 – High-Performance Coatings

E. Manual Actuators:

1. Unless otherwise indicated, manually actuated butterfly valves shall be equipped with a handwheel and 2-inch square actuating nut and position indicator. Screw-type (traveling nut) actuators will not be permitted for valves 30-inches in diameter and larger.
2. Manually actuated butterfly valves located in a trench shall be equipped with a yoke-style extension stem and floor stand with a handwheel and position indicator. Extension stems shall be set to allow handwheel access 3-feet above floor grating sections.

F. Electric Actuators: Electric actuators shall meet the requirements of AWWA C541. Electric actuators in open/close service shall be rated to produce output torque of at least 1.5 times the required valve maximum seating or maximum dynamic torque, whichever is greater. For valves in modulating service with dynamic torque exceeding the seating torque, the rated output torque of the actuator shall be twice the dynamic torque required by the valve. Actuator rated torque is defined as pullout torque rated at 10 percent below the rated voltage of the motor. The torque switch shall be field set at no greater than 60 percent and 50 percent of the maximum actuator rated torque for open/close service and modulating service, respectively. After plant startup, the manufacturer shall prepare a certification including a torque curve to demonstrate that the torque requirements have been met.

G. Manufacturers, or Equal

1. DeZURIK Water Controls Corporation
2. Henry Pratt Company

PART 3 -- EXECUTION

3.01 INSTALLATION

- A. Install butterfly valves with the shaft in the horizontal direction, unless otherwise indicated.
- B. Exposed butterfly valves shall be installed with a means of removing the complete valve assembly without dismantling the valve or operator. Installation shall be in accordance with Section 40 05 51 – Common Requirements for Process Valves.

END OF SECTION

SECTION 40 05 65.10 – CHECK VALVES

PART 1 -- GENERAL

1.01 SUMMARY

- A. The Contractor shall provide check valves and appurtenances, complete and operable, in accordance with the Contract Documents.
- B. The requirements of Section 40 05 51 – Common Requirements for Process Valves apply to this Section.

1.02 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

A. Reference Specifications

40 05 51	Common Requirements for Process Valves
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B. Reference Standards

American Society of Mechanical Engineers (ASME)	
ASME B1.20.1	Pipe Threads, General Purpose (inch)
ASME B16.1	Cast Iron Pipe Flanges and Flanged Fittings
ASME B16.5	Pipe Flanges and Flanged Fittings
American Water Works Association (AWWA)	
AWWA C508	Swing-Check Valves for Waterworks Service
ASTM International (ASTM)	
ASTM A48	Gray Iron Castings
ASTM A126	Gray Iron Castings for Valves, Flanges, and Pipe Fittings
ASTM B16	Free-Cutting Brass Rod, Bar, and Shapes for Use in Screw Machines
ASTM B148	Aluminum-Bronze Castings
ASTM B584	Copper Alloy Sand Castings for General Applications
ASTM B763	Copper Alloy Sand Castings for Valve Application

1.03 CONTRACTOR SUBMITTALS

- A. Furnish submittals in accordance with Section 40 05 51 – Common Requirements for Process Valves.

PART 2 -- PRODUCTS

2.01 SWING CHECK VALVES (3-INCHES AND LARGER)

- A. General: Swing check valves for water, sewage, sludge, and general service shall be of the outside lever and spring or weight type, in accordance with AWWA C508 - Swing-Check Valves for Waterworks Service, 2-in. through 24-in. NPS, unless otherwise indicated, with full-opening passages, designed for a water-working pressure of 150 psi. Units shall have a flanged cover piece to provide access to the disc. Where indicated, swing check valves shall be provided with position indicators.

- B. Body: The valve body and cover shall be of cast iron conforming to ASTM A126 - Gray Iron Castings for Valves, Flanges, and Pipe Fittings, with flanged ends conforming to ASME B16.1 - Cast Iron Pipe Flanges and Flanged Fittings, Class 25, 125, 250, and 800, or be mechanical joint ends, as indicated.
- C. Disc: The valve disc shall be of cast iron, ductile iron, or bronze conforming to ASTM B584 - Copper Alloy Sand Castings for General Applications.
- D. Seat and Rings: The valve seat and rings shall be of bronze conforming to ASTM B584 or ASTM B148 - Aluminum-Bronze Castings or of Buna-N.
- E. Hinge Pin: The hinge pin shall be of bronze or stainless steel.
- F. Limit Switches: Limit switches shall be provided on check valve swing arms where indicated. Switches shall be roller lever rotary actuated type, with contacts rated for 10 amp at 120 VAC. Switches shall be located to actuate when the check valve is fully closed and deactivate when the valve begins to open. Switches shall be **Honeywell Microswitch Model 1LS1, Square D 9007 C**, or equal
- G. Manufacturers, or Equal
 - 1. DeZurik/APCO
 - 2. Kennedy Valve
 - 3. Mueller Company
 - 4. Stockham Valves and Fittings
 - 5. GA Industries

2.02 SWING CHECK VALVES (2-1/2 INCHES AND SMALLER)

- A. General: Swing check valves for steam, water, oil, or gas in sizes 2-1/2 inches and smaller shall be suitable for a steam pressure of 150 psi and a cold-water pressure of 300 psi. Units shall have screwed ends unless otherwise indicated, and screwed caps.
- B. Body: The valve body and cap shall be of bronze conforming to ASTM B763 - Copper Alloy Sand Castings for Valve Application, or ASTM B584 with threaded ends conforming to ASME B1.20.1 - Pipe Threads, General Purpose (inch).
- C. Disc: Valves for steam service shall have bronze or brass discs conforming to ASTM B16 - Free-Cutting Brass Rod, Bar, and Shapes for Use in Screw Machines, and for cold water, oil, and gas service replaceable composition discs.
- D. Hinge Pin: The hinge pins shall be of bronze or stainless steel.
- E. Manufacturers, or Equal
 - 1. Crane Company
 - 2. Milwaukee Valve
 - 3. Stockham Valves and Fittings
 - 4. Wm. Powell Company

2.03 INTERNAL SPRING-LOADED CHECK VALVES (GLOBE STYLE)

- A. General: Internal spring-loaded check valves for water pumps, compressors, gas, air, and steam shall be of the full-flow internal spring-loaded poppet type. The valves shall be designed for a water-working pressure of not less than 150 psi unless otherwise indicated.
- B. Body: The bodies of valves 3-inches and larger shall be of cast iron conforming to ASTM A126 with 125 lb flanged ends conforming to ASME B16.1 unless otherwise indicated. Where necessary, there shall be a positive, watertight seal between the removable seat and the valve body. The stem guide shall be integrally cast with the body or screwed into the body.
- C. Valves smaller than 3-inches shall have bronze bodies with screwed ends conforming to ASME B1.201, suitable for a minimum working pressure of 200 psi, and a temperature of 250 degrees F, unless otherwise indicated. The type of bronze shall be suitable for the intended service.
- D. Disc and Stem: The disc and stem of all valves in sizes 3-inches and larger shall be of bronze conforming to ASTM B584 - Copper Alloy Sand Castings for General Applications, or stainless steel. The stem shall have 2-point bearings. The downstream bearing shall have a bronze or other suitable bushing, to provide a smooth operation.
- E. Valves smaller than 3-inches shall have discs and retaining rings of Teflon, nylon, or other suitable material, and stems of bronze, brass, or stainless steel, suitable for the intended service.
- F. Stem Guide: The stem guide shall be either firmly fixed in the valve body to prevent it from sliding into the adjacent pipe and damaging the pipe lining, or the valve manufacturer shall provide each valve with one matching flange compatible with the adjacent pipe and its lining to prevent damage to the lining. The compatible flange shall be part of the Shop Drawing submittal.
- G. Seat: Valves for general service at temperatures up to 250 degrees F shall have bubble-tight shut-off with resilient seats of Buna-N, Teflon, or other suitable material. Valves for steam service and temperatures over 250 degrees F shall have metal-to-metal seating of bronze or stainless steel, as recommended by the manufacturer for the specific service condition. Resilient seats shall be firmly attached to the seating ring by compression molding or other acceptable method.
- H. Spring: Valves in sizes 3-inches and larger shall have Type 316 stainless steel springs, and valves smaller than 3-inches shall have stainless steel or beryllium copper springs, as suitable for the service. The spring tension of the valves shall be designed for the individual pressure condition of each valve.
- I. Manufacturers, or Equal
 - 1. DeZurik/APCO
 - 2. CPV (Combination Pump Valve Company)
 - 3. Miller Valve Co., Inc.
 - 4. VAL-MATIC (Valve and Manufacturing Corporation)

2.04 DOUBLE-LEAF CHECK VALVES

- A. General: Double-leaf check valves for air and gas service and where indicated, shall be of the wafer-type designed to fit between ANSI B16.1 flanges for 125 lb rating. The check valve leaves shall be spring-loaded. Flow from one direction shall cause the valve to open, and upon valve shutoff, the spring shall shut the valve leaves before reverse flow starts, acting at a point of zero velocity, for non-slam closure. The spring-tension of each valve shall be designed for the individual operating condition. For check valves installed in discharge piping of multi-stage blowers, the spring tension and seat material shall be suitable for the pressure, temperature, and air or gas service per the blower manufacturer recommendations.
- B. Body: The valve body shall be of cast iron conforming to ASTM A126 with integrally-cast seat, rated for minimum 150 lb working pressure at up to 250 degrees F.
- C. Leaves: The leaves shall be of bronze, aluminum bronze, or ductile iron, revolving on stainless steel or monel hinge pins with retainers.
- D. Seat: The valves shall have resilient seats for bubble-tight shut-off, suitable for temperatures up to 250 degrees F without sticking. The seats shall be Buna-N, Viton, or other suitable material for the intended purpose. The seat rings shall be firmly attached to a shoulder cast in the body or to the disc by compression-molding or similar acceptable method.
- E. Springs: The springs shall be of Type 316 stainless steel or Inconel, as best suited for the service condition.
- F. Manufacturers, or Equal
 - 1. DeZurik/APCO
 - 2. Proquip International
 - 3. VAL-MATIC (Valve and Manufacturing Corporation)

2.05 RUBBER FLAPPER SWING CHECK VALVES

- A. General: Rubber flapper swing check valves for water, sewage, sludge, and abrasives shall have full pipe size flow areas, one moving part only, and body seats at 45 degrees to permit horizontal and vertical up-flow. Valves shall be designed for a minimum water-working pressure of 150 psi, with a flanged cover plate holding down the rubber flapper. The valves shall be of the non-clog design.
- B. Body: The valve body and cover shall be of cast iron conforming to ASTM A126 with flanged ends conforming to ASME B16.1. There shall be a threaded tapping in the bottom of the body for insertion of a back-flow device, and provision for mounting of a signal switch.
- C. Disc: The valve disc or flapper shall be of Buna-N or other best-suited elastomer one-piece construction, precision molded, with integral O-ring type sealing surface, steel and nylon or fabric reinforced, with non-slam closing action through a 35-degree disc stroke, for bubble-tight shut off at high and low pressures.
- D. Manufacturers, or Equal
 - 1. APCO (Valve and Primer Corporation)

2. VAL-MATIC (Valve and Manufacturing Corporation)

PART 3 -- EXECUTION

3.01 GENERAL

- A. Valves shall be installed in accordance with provisions of Section 40 05 51 – Common Requirements for Process Valves.

END OF SECTION

SECTION 40 05 85 – MISCELLANEOUS VALVES

PART 1 -- GENERAL

1.01 THE SUMMARY

- A. The Contractor shall provide miscellaneous valves and appurtenances, complete and operable, in accordance with the Contract Documents.
- B. The requirements of Section 40 05 51 – Common Requirements for Process Valves, apply to this Section.

1.02 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

A. Reference Specifications

26 00 10	Electrical General Requirements
40 05 51	Common Requirements for Process Valves

B. Reference Standards

American Water Works Association (AWWA)	
AWWA C511	Reduced-Pressure Principle Backflow Prevention Assembly
National Electrical Manufacturers Association (NEMA)	
Underwriters Laboratories (UL)	

1.03 CONTRACTOR SUBMITTALS

- A. Furnish submittals in accordance with Section 40 05 51 – Common Requirements for Process Valves.

PART 2 -- PRODUCTS

2.01 AIR-VACUUM AND AIR-RELEASE VALVES

- A. Air and Vacuum Valves: Air and vacuum valves shall be capable of venting large quantities of air while pipelines are being filled, and allowing air to re-enter while pipelines are being drained. They shall be 3", with flanged or screwed ends to match piping. Outlet and orifice sizes shall be based on manufacturers design. Bodies shall be of high-strength cast iron. The float, seat, and moving parts shall be constructed of Type 316 stainless steel. Seat washers and gaskets shall be of a material insuring water tightness with a minimum of maintenance. Valves shall be designed for minimum 150 psi water-working pressure, unless otherwise indicated.
- B. Air-Release Valves: Air-release valves shall vent accumulating air while system is in service under pressure and be of the size indicated. Valves shall meet the same general requirements as indicated for air and vacuum valves except that the vacuum feature will not be required. Valves shall be designed for a minimum water-working pressure of 150 psi, unless otherwise indicated.
- C. Combination Air Valves: Combination air valves shall combine the characteristics of air and vacuum valves and air release valves by exhausting accumulated air in systems under pressure and releasing or re-admitting large quantities of air while a system is being filled or drained, respectively. Valves shall have the same general requirements as indicated for air and vacuum valves.

D. Manufacturers, or Equal

1. APCO (Valve and Primer Corporation)
2. Crispin - Multiplex Manufacturing Company
3. GA Industries
4. Val-Matic (Valve and Manufacturing Corporation)

2.02 PRESSURE SAFETY VALVE

A. Safety relief valve shall be free from all imperfections and defects. Safety relief valve shall be ASME section VIII certified for liquid service. Valve shall incorporate the following features:

1. Angle style valve with 2-inch minimum inlet diameter MNPT connection and 3-inch FNPT discharge unless otherwise indicated.
2. Bronze / brass body and bonnet, stainless steel spring, wear ring and disc.
3. EPDM seats and seal material
4. Threaded cap, full nozzle design, orifice inlet size to 2-inch diameter minimum, pump, 3-inch diameter for the discharge header minimum.
5. EPDM seat and seal material.
6. Valve pressure / temperature limits: 3 to 300 psig / -320 - 460 °F

B. Set pressure = Field adjustable to 171 psig.

2.03 BACKFLOW PREVENTER VALVES

A. General

1. Provide backflow preventers that work on the reduced pressure principle.
2. Provide drain lines with air gaps.
3. The backflow preventer valves shall be in accordance with AWWA C511 – Reduced-Pressure Principle Backflow Prevention Assembly.

B. Construction

1. The preventers shall consist of 2 spring-loaded check valves, an automatic differential pressure relief valve, drain valves, and shut-off valves.
2. The body material shall be bronze or cast iron, for a working pressure of not less than 150 psig, with bronze or stainless-steel trim.

C. Maintenance Access

1. Provide separate access covers for the check valves and the relief valve.
2. Provide top-entry access to check valve components.

D. Manufacturers, or Equal

1. Febco (CMB Industries)
2. Watts, ACV
3. Wilkins Regulator Division (Zurn Industries).

2.04 SOLENOID VALVES

A. Solenoid valves shall be of the size, type, and class indicated and shall be designed for not less than 150 psi water-working pressure. Valves for water, air, or gas service shall have brass or bronze body with screwed ends, stainless steel trim and spring, Teflon or other resilient seals with material best suited for the temperature and fluid handled. Unless otherwise indicated, for chemicals and corrosive fluids, solenoid valves with PVC, CPVC, polypropylene (PP), polyvinylidene fluoride (PVDF), or Teflon materials of construction, suitable for the specific application shall be provided. Enclosures shall be NEMA rated in accordance with the area designations of Section 26 00 10 - Electrical General Requirements. Coil ratings shall be for continuous duty. For electrical characteristics see the electrical Drawings or Specifications.

B. Manufacturers, or Equal

1. For general duty
 - a. Automatic Switch Co. (ASCO), Model RED HAT
 - b. Skinner Valve (Parker Hannifin Corporation)
 - c. Magnatrol Valve Corporation
 - d. J. D. Gould Co.
2. Metallic valves for corrosive fluids
 - a. Valcor Engineering Corporation
3. Plastic valves for corrosive fluids
 - a. +GF+ Plastic Systems, Inc.
 - b. Spears Mfg. Co.

PART 3 -- EXECUTION

3.01 INSTALLATION

- A. Backflow preventers shall be installed in potable water lines where required by applicable codes or regulations, wherever there is any danger of contamination, and where indicated.
- B. Valves shall be installed in accordance with the manufacturer's printed recommendations, and with this Section.

- C. Backflow preventers, as well as air and vacuum release valves, shall have piped outlets to the nearest acceptable drain, firmly-supported, and installed in such a way as to avoid splashing and wetting of floors and obstruction of traffic.

END OF SECTION

SECTION 40 61 00 - PROCESS CONTROL AND ENTERPRISE MANAGEMENT SYSTEMS

PART 1 -- GENERAL

1.1 THE SUMMARY

- A. The CONTRACTOR shall provide Process Control and Instrumentation Systems (PCIS) complete and operable, in accordance with the Contract Documents. For the purpose of this CONTRACT, PCIS is synonymous and interchangeable with supervisory control and data acquisition (SCADA) and distributed control system (DCS), where applicable. The requirements of this Section apply to every component of the PCIS unless indicated otherwise.

B. Responsibilities

1. The CONTRACTOR, through the use of PRO-TECH Systems Group (System Integrator) and qualified electrical and mechanical installers, shall be responsible to the OWNER for the implementation of the PCIS and the integration of the PCIS with other required instrumentation and control devices.
2. Due to the complexities associated with the interfacing of numerous control system devices, it is the intent of these specifications that the System Integrator will be responsible to the CONTRACTOR for the integration of the PCIS with existing devices and devices provided under this and other Divisions with the objective of providing a completely integrated control system free of signal incompatibilities.
3. The CONTRACTOR shall request the OWNER to demonstrate that all existing equipment that is to be reused or interfaced with in this project works properly for the intended function. In the event the existing equipment does not work, the issue should be brought up in the preconstruction/ pre-submittal meeting(s).
4. As a minimum, the implementation of the PCIS by the CONTRACTOR shall include the following WORK:
 - a. Integrate the PCIS with existing devices and systems provided under this and other Divisions
 - b. Prepare the required PCIS submittals
 - c. Design and develop project-wide loop diagrams including those associated with equipment provided under other Divisions and OWNER-furnished and existing equipment
 - d. Design and develop control panel drawings
 - e. Field verify existing conditions
 - f. Prepare factory and field test submittals
 - g. Prepare training plan
 - h. Prepare spare parts submittal
 - i. Procure hardware and software

- j. Provide PLC, OIT and HMI programming
 - k. Configure and factory test the PCIS
 - l. Bench calibrate instruments and verify calibration after installation
 - m. Terminate signals inside control and network panels; terminate communication and network devices and nodes
 - n. Supervise and coordinate installation and termination of field signals, power, and utilities associated with the PCIS. Resolve signal, power, or functional incompatibilities between the PCIS and new and existing interfacing devices.
 - o. Loop test in accordance with the loop diagrams. Validate and certify loops
 - p. Oversee, document, and certify system commissioning
 - q. Conduct system performance test
 - r. Prepare technical manuals
 - s. Conduct training classes
 - t. Prepare PCIS as-built final construction drawings
5. Any Instrumentation Supplier responsibilities in addition to the list above are at the discretion of the CONTRACTOR and the Instrumentation Supplier. Additional requirements in this Section and throughout Division 40 that are stated to be the CONTRACTOR's responsibility may be performed by the Instrumentation Supplier if the CONTRACTOR and Instrumentation Supplier so agree.

C. RELATED WORK AND REQUIREMENTS SPECIFIED ELSEWHERE

- 1. All electrical work required under this section shall conform to the requirements of this Section and the applicable requirements of the Sections in Division 01, Division 26, Division 27 and Division 28.

1.2 PRICE AND PAYMENT PROCEDURE

- A. General: The CONTRACTOR shall develop a schedule of values based upon the payment milestones noted below for inclusion in the Supplementary to the General Conditions Section 012973.
- B. Payment Milestones: This schedule lists the percentage of the lump sum price of Instrumentation which will be payable to the CONTRACTOR upon task completions. Payment shall be in accordance with the General Conditions.

- | | |
|--|------------|
| 1. Hardware Equipment Submittal approved | 5 percent |
| 2. Project-wide Loop Drawing Submittal approved | 10 percent |
| 3. Control Panel Engineering Submittals approved | 5 percent |
| 4. Final Technical Manual submitted | 5 percent |

- | | |
|---|------------|
| 5. Completion of testing and commissioning accepted | 30 percent |
| 6. Thirty-day performance test successfully completed | 25 percent |
| 7. Notice of acceptance issued | 20 percent |

1.3 REFERENCE SPECIFICATIONS, CODES AND STANDARDS

- A. Without limiting the generality of other requirements of these Specifications, all WORK specified herein shall conform to or exceed the applicable requirements of the referenced documents to the extent that the requirements therein are not in conflict with the provisions of this Section; provided, that where such documents have been adopted as a code or ordinance by the public agency having jurisdiction, such code or ordinance shall take precedence.
- B. Definitions
 - 1. System Supplier: The System Supplier shall be a single firm, corporation, or other entity assuming full responsibility through the CONTRACTOR to perform all engineering and to select, furnish, program, configure, integrate, supervise the installation and connections, test, calibrate, and place into operation all instrumentation, controls, communication hardware and software. The System Supplier shall specialize and have an experienced engineering and technical staff in the design, integration, and supply of systems similar to the one in these Contract Documents. The term "System Supplier" shall mean the same as "SCADA System Supplier" or "PCIS Supplier."
- C. The PCIS WORK shall conform to or exceed the applicable regulations, standards, specifications, and codes which are referenced in Section 014219 Reference Standards, and current as of the date of the final inspection for this Contract, including, but not limited to, those which are established by the following sources:
 - 1. The International Society of Automation (ISA)
 - 2. National Electrical Code (NEC)
 - 3. National Fire Protection Association (NFPA)
 - 4. Institute of Electrical and Electronic Engineers (IEEE)
 - 5. Occupational Safety and Health Administration (OSHA)
 - 6. American National Standards Institute (ANSI)
 - 7. National Electrical Manufacturers Association (NEA)
 - 8. Insulated Cable Engineers Association (ICEA)
 - 9. Local Power and Telephone Companies
 - 10. Local Authorities having jurisdiction over the work
 - 11. Federal Communication Commission (FCC)

12. Underwriter Laboratory (UL)

- D. Where the requirements set forth in these Specifications or on the Drawings are greater or more rigid than the mandatory requirements referenced above, the applicable Specifications or Drawings shall govern.
- E. In the case of conflict between any mandatory requirements and Specifications or Drawings, the mandatory requirement shall be followed in each case, but only after submitting such proposed changes to the ENGINEER for approval.
- F. Nothing contained in these Specifications or shown on the Drawings will be so construed to conflict with any national, state, municipal, or local laws or regulations governing the installation of work specified herein, and all such acts, ordinances, and regulations, including the National Electrical Code, are hereby incorporated and made a part of these Specifications. All such requirements will be satisfied by the CONTRACTOR at no additional expense to the OWNER.
- G. The Drawings and Specifications are complementary to each other; what is called for by one shall be as binding as if called for by both. If a conflict between Drawings and Specifications is discovered, this shall be referred to the ENGINEER as soon as possible for resolution. Should a conflict exist between the Drawings, Specifications, and/or mandatory requirements (i.e., codes, ordinances, etc.), it will be assumed that the more expensive method has been estimated, unless such alternate has been agreed to prior to submission of bids.

1.4 ADMINISTRATIVE REQUIREMENTS

A. Presubmittal Conference

1. The CONTRACTOR shall arrange and conduct a Presubmittal Conference within 30 Days after award of the Contract. The purpose of the Presubmittal Conference is to review and approve the manner in which the CONTRACTOR intends to carry out its responsibilities for Shop Drawing submittal on the WORK to be provided under this Section. The CONTRACTOR, the System Supplier, and the ENGINEER shall attend. Both the CONTRACTOR and the ENGINEER may invite additional parties at their discretion.
2. Before preparing the submittals the CONTRACTOR shall meet with the OWNER and visit the project site(s) to obtain information and inventory regarding the existing conditions. Interface to existing equipment, control and monitoring circuits shall also be reviewed. During the inventory the CONTRACTOR shall determine the location of the new equipment that is part of this contract. Any major conflicts with the contract documents shall be brought to the ENGINEER's attention at the pre-submittal conference. The CONTRACTOR shall also review the available as built drawings.
3. The CONTRACTOR shall allot two, 8 hour days for the pre-submittal conference.
4. The CONTRACTOR shall present the following for discussion at the pre-submittal conference:
 - a. A list of equipment and materials required for the PCIS and the manufacturer's name and model number for each proposed item.

- b. A list of requests for clarifications (RFC) or information (RFI) to the contract documents along with a brief explanation of each. Resolution shall be subject to a separate formal submittal and review by the ENGINEER.
 - c. An exact one-to-one sample of each type of submittal herein.
 - d. A bar-chart type schedule for system-related activities from the Presubmittal Conference through start-up and training. Dates of submittals, design, fabrication, programming, factory testing, deliveries, installation, field testing, and training shall be shown. The schedule shall be subdivided to show activities relative to each major item or group of items when everything in a given group is on the same schedule.
5. The CONTRACTOR shall take minutes of the pre-submittal conference, including events, questions, and resolutions. Prior to adjournment, attendees must concur with the accuracy of the minutes and sign accordingly.

1.5 ACTION SUBMITTALS / INFORMATIONAL SUBMITTALS

- A. The CONTRACTOR shall provide submittals in accordance with Section 01 33 00- Contractor Submittals and the additional submittal requirements specified in this Section, in Division 40, and the following:
1. The CONTRACTOR shall coordinate the PCIS part of the WORK so that a complete instrumentation and control system will be provided and will be supported by accurate Shop Drawings and as-built drawings.
 2. The submittals and their schedules shall be in accordance with the requirements listed below: Any incomplete submittal will be rejected and returned without comments.
 3. Interface between instruments, motor control centers, engines, starters, control valves, flowmeters and other equipment related to the PCIS shall be included in the shop drawing submittal. Interface between existing equipment, instruments and control panels shall also be included,
 4. Exchange of Technical Information: During the period of preparation of these submittals, the CONTRACTOR shall authorize a direct, informal liaison with the ENGINEER for exchange of technical information. As a result of this liaison, certain minor refinements and revisions in the systems as indicated may be authorized informally by the ENGINEER, but will not alter the scope of WORK or cause increase or decrease in the Contract Price. During this informal exchange, no oral statement by the ENGINEER shall be construed to give approval of any component or method, nor shall any statement be construed to grant exception to or variation from these Contract Documents.
 5. Symbols and Nomenclature: In these Contract Documents, systems, meters, instruments, and other elements are represented schematically, and are designated by symbols as derived from Instrument Society of America Standard ISA S5.1 - Instrumentation Symbols and Identification. The nomenclature and numbers designated herein and on the Drawings shall be employed exclusively throughout Shop Drawings, and similar materials. No other symbols, designations, or

nomenclature unique to the manufacturer's standard methods shall replace those prescribed above, used herein, or on the Drawings.

B. Shop Drawings Submittal Organization

1. Shop Drawings shall include the letter head or title block of the System Supplier. The title block shall include, as a minimum, the System Supplier's registered business name and address, project name, drawing name, revision level, and personnel responsible for the content of the drawing.
2. Organization of the Shop Drawing submittals shall be compatible with eventual submittals for later inclusion in the Technical Manual. Submittals not so organized will not be accepted.
3. For a project with multiple sites the CONTRACTOR shall provide a separate and unique set of drawings for each site.
4. Drawings that require more than one sheet due to space limitation or continuation in the subject of the drawings (e.g. loop diagrams, etc.) shall be given the same drawing number but with different sheet number (e.g. sheet 1 of x, sheet 2 of x, etc.).
5. Each submittal shall include a complete index appearing in the front of each bound submittal volume. Drawings and/or system groups shall be separated by labeled tags. The organization of the initial shop drawing submittal required above shall be compatible to eventual inclusion with the Technical Manuals submittal and shall include final alterations reflecting as-built conditions.
6. Interfaces between new and existing instruments, motor starters, control valves, variable speed drives, flow meters, chemical feeders, panels, and other equipment related to the PCIS shall be included in the Shop Drawing submittal.

C. Field Instrument Submittal

1. Submittal Schedule: The CONTRACTOR shall submit for approval a complete field and process instrument submittal, **all at one time, within 60 calendar days** after the date of Notice to Proceed is given to the CONTRACTOR.
2. Submittal Contents: The submittal shall include a complete index which lists each device by tag number, type, and manufacturer in accordance with the specified data sheets provided in this CONTRACT. A separate manufacturer technical brochure or catalog sheet shall be included with each specified instrument data sheet. If, within a single system or loop, a single instrument is employed more than once, one manufacturer brochure or catalog sheet may cover multiple identical uses of that instrument in that system. Each manufacturer brochure or catalog sheet shall include a list of tag numbers for which it applies. System groups shall be separated by labeled tags. Special options and features which are furnished shall be identified.

D. System Hardware Submittal:

1. Submittal Schedule: The CONTRACTOR shall submit for approval a complete system hardware submittal, **all at one time, within 90 calendar days** after the date of Notice to Proceed is given to the CONTRACTOR. This submittal shall be submitted together with the submittal for the System Architecture, and

Communication Diagrams submittal and the Project-Wide Wiring Diagrams and Panel Drawings submittal specified below.

2. Submittal Contents:

- a. The submittal shall be for the hardware specified under Sections 40 62 02 – PLC-Based Control System Hardware and 40 67 00 – Process Controls Equipment Panels and Racks.
- b. The submittal shall include a complete index which lists each device by type, and manufacturer in accordance with the contract documents. A separate manufacturer technical data sheet or brochure shall be included for each hardware component. If, within a single system a single component is employed more than once, one manufacturer technical data sheet or brochure may cover multiple identical uses of that component in that system. Special options and features which are furnished shall be identified.
- c. The submittal shall include load calculations and size of the various UPS systems to demonstrate that the UPS is able to accommodate present and future load requirements, as well as overload capacity requirements.
- d. Spare Parts and Tools List: A list of spare parts and tools shall be submitted, covering items which are specified and furnished under this Contract. The list shall include the name, address, and phone number of manufacturer and manufacturer's local service representative of these parts. The list shall also include recommended spare parts and tools, quantities and prices from which the OWNER will select the "Additional Recommended Spare Parts and Tools".
- e. Control Room furniture

E. System Software Submittal

1. Submittal Schedule: The CONTRACTOR shall submit for approval a complete system hardware submittal, **all at one time, within 90 calendar days** after the date of Notice to Proceed
2. Submittal Contents:
 - a. The submittal shall be for the software specified under Section 40 68 00 – PLC-Based Control System Software. This submittal shall be provided in a singular all inclusive submittal and be made separately from other PCIS submittals.
 - b. The software submittal shall include but not be limited to:
 - 1) Vendor documentation that supports that the specific functional requirements of the contract documents Section 40 68 00 – PLC-Based Control System Software are met. Details shall include complete description of the standard (baseline) application Human Machine Interface (HMI) software programs, operating system and utility programs to be furnished, including modifications and explanation of how the specific functional requirement will be met. A cross reference between the specification and the software submittal shall be provided in order to provide the ENGINEER the ability to identify how each specified section or function is being met by the CONTRACTOR.

- 2) A functional design report of the implemented control functions using as a reference the strategies specified in Section 40 61 96 – Process Control Descriptions. The report shall include:
 - a) Control narratives and their implementation, which describe all monitoring and control functions (e.g., commands, mission, anticipated action, etc.) on a loop by loop or site by site basis in the PLC. It shall also describe special control functions in the server(s), including peer-to-peer communication. These narratives will be used for the operating instructions and inclusion in the Operations and Maintenance Manuals.
 - b) Control narratives shall enumerate the signal point name, signal description, associated PLC number, associated graphic displays, system functions activated by the signal (i.e., interlocks, alarms, logs, etc.)
 - c) A complete set of all available software algorithms with annotation of:
 - 1) Individual coil register and variable description
 - 2) Program, group of program, subroutine, and complete rung detail comments
 - 3) Memory, coil, register, and variable usage mapping
 - d) Description of how the HMI software will be configured to meet the requirements specified in Section 40 68 00 – PLC-Based Control System Software.
 - e) Copies of the configured PLC control software shall be provided in the technical manual together with a CD.

F. Input and Output (I/O) Data List:

1. Submittal Schedule: The CONTRACTOR shall submit for approval a complete I/O list(s), **all at one time, within 90 calendar days** after the date of Notice to Proceed is given to the CONTRACTOR.
2. Submittal Contents:
 - a. The submittal shall include a complete listing of the PCIS I/O data base listing for each data point relevant parameters such as range, active state, contact orientation, limits, incremental limits, and I/O hardware address. The list shall be divided and grouped on a site by site basis and PLC assignment, and divided into type of I/O's (card type). The I/Os shall be identified by the location of the card (slot no.) and input/output point number. The I/O list shall be formatted in MS Excel.
 - b. In addition to the active I/O's, the list shall also include the implemented spare I/O's and the available I/O's remaining on the I/O board.

G. System Architecture and Communication Diagrams

1. Submittal Schedule: The CONTRACTOR shall submit for approval a complete set of system architecture and communication diagrams **all at one time within 120 calendar days** after the date of Notice to Proceed is given to the CONTRACTOR. This submittal shall be submitted together with the System Hardware submittal and the Project-Wide Wiring Diagrams and Panel Drawings submittal specified herein.
2. Submittal Contents: System Architecture and Communication System Diagrams: The CONTRACTOR shall develop and submit project-wide system architecture and communication diagrams, which present the system architecture, the network(s), and radio communication as applicable. The submittal shall include a set of drawings that presents the following as applicable:
 - a. System architecture and network (copper and fiber optic) physical topology schematic, including servers, workstations, hardware nodes, network hardware such as routers, cabling converters, etc., and connections.
 - b. System architecture and network (copper and fiber optic) physical topology schematic, including servers, workstations, hardware nodes, network hardware such as routers, cabling converters, etc., and connections.
 - c. Radio communication, cabling and connections including within a panel and the antenna.

H. Project-Wide Wiring Diagrams and Panel Drawings Submittal:

1. Submittal Schedule: The CONTRACTOR shall submit for approval a complete set of project-wide wiring diagrams (PWWD) and panel drawings, **all at one time within 120 calendar days** after the date of Notice to Proceed is given to the CONTRACTOR. The PWWD and panel drawings shall be a singular complete hard copy bound package and accompanied with a PDF on a CD. This submittal shall be submitted together with the System Hardware submittal and the System Architecture and Communication Diagrams submittal specified herein.
2. Submittal Contents: The PWWD and panel drawings shall be submitted as a single and comprehensive set of drawings. The submittal shall include a complete index in the front of each part of the submittal. The drawings shall be indexed by systems, sites, or process areas. Diagrams shall be tagged in a manner consistent with the Contract Documents and shall include the following:
 - a. Project-Wide Wiring Diagrams: The PWWD shall define and document the contents of each analog and discrete monitoring, alarming, hardware interlock, and control functions associated with equipment provided under Division 40 sections. The PWWD shall also cover equipment provided under sections in other Divisions, existing, and OWNER-furnished equipment. The PWWD shall also include both field and panel wiring diagrams.
 - 1) Drawings showing definitive diagram for every analog and discrete instrumentation loop system. These diagrams shall show and identify each component in each loop or system using legend and symbols from the standards in the Contract Documents. The wiring diagrams shall be presented on an 11"x17" drawing with no more than 10 loops per drawing.
 - 2) In general, loops shall be grouped and organized by PLC (if used) and the I/O cards within the PLC. Each I/O card shall be presented on a

separate sheet(s) and on the right side of the drawing. The type of card, part number and its slot location shall be identified. Each I/O shall be identified as well as its location on the card and its address. Existing, spare, and future I/Os shall also be shown. Power supply wiring to the card/loops, wire colors, and terminal numbers shall be shown on the wiring diagrams. The I/O cards, the loops and any device in the loop shall be shown together. Each loop shall be complete, including the source/destination within new or existing panels, device(s) in the loop, field connection panels or field junction boxes, field and PLC interface terminal blocks and wire numbers.

- 3) In addition wiring diagrams shall show the following details
 - a) Functional name of each loop
 - b) Reference name, drawing, and loop diagram numbers for any signal continuing off the wiring diagram sheet.
 - c) MCC panel, circuit, and breaker numbers for power feeds to the loops and instrumentation.
 - d) Wiring type, size and color
 - e) Designation, and if applicable, terminal assignments associated with every manhole, pull box, junction box, conduit in which wiring is to be located, and panel through which the loop circuits pass.
 - f) Vendor panel, instrument panel, conduit, junction boxes, equipment and SCADA terminations, termination identification wire numbers and colors, power circuits, and ground identifications.
- 4) Wiring diagrams shall be developed for loops in equipment vendor-supplied packages, equipment provided under Division 40, and OWNER-furnished equipment.\
- b. Panel Wiring Diagrams: Panel wiring and/or piping diagrams shall be prepared in concert with the PWWD and shall include the following information:
 - 1) Name of panel
 - 2) Power distribution schematic diagrams associated with each panel or system (120VAC, 24VDC and other DC systems, control circuits). The schematic diagram shall show source of power for the panel (circuit breaker panel and breaker) and fuses. All power backup system distribution shall also be shown.
 - 3) Schematic diagrams for control circuits in accordance with ANSI standards. The diagrams shall show complete details on the circuit interrelationship of all devices within and outside each Control Panel. Including primary measurement and control devices.
 - 4) Communication diagram(s) for the equipment inside the panel.
 - 5) Interfaces with existing control and monitoring systems. The CONTRACTOR shall furnish all necessary diagrams that depict any and

all modifications made to existing measurement and control circuits, equipment and wiring. It is the responsibility of the System Supplier to ascertain actual field conditions of the existing circuits, equipment and wiring. The CONTRACTOR may request copies of as built drawings and data that the OWNER can provide that show such existing conditions. Lack of such drawings shall not alleviate the contractual responsibility to ascertain and implement interfaces and modifications to existing measurement and control circuits, equipment and wiring.

- 6) Surge protection and signal and safety grounding circuits
 - 7) Wiring type and piping size and material
 - 8) Terminal block numbers and wire numbers
- c. Panel Drawings: Panel drawings, including console, and cabinet layout drawings, shall be prepared and submitted for each panel and shall include the following information: These drawings shall include enough other details to define exactly the style, the contents, and overall appearance of the panel assembly.
- 1) Name of Panel.
 - 2) Panel Dimensions; front, side, and plan views and layout to scale.
 - 3) Arrangement of internally and externally mounted instruments and equipment to scale. Note: Control panel layouts shown on the Contract Drawings are diagrammatic.
 - 4) Location of terminal blocks, electrical devices, and conduit entry location(s).
 - 5) Tag number or item number and functional name of items mounted in and on panel, console, or cabinet.
 - 6) Nameplate legend which includes text, letter size, and colors to be used.
 - 7) Complete and detailed Bills of Materials shall include all items within a panel and shall be presented on the panel layout drawing. The bill of material list shall include quantity, description, manufacturer, and part number.
 - 8) Panel mounting information, including conduit entrance location.
 - 9) Communication hardware installation, such as radio, mast and antenna.
 - 10) Assembly and construction drawings. These drawings shall include dimensions, identification of all components, construction material and gauge, surface preparation and finish data, panel door locks and hinge mechanism, nameplates, and the like.

I. Control Room Layout and Furniture Submittal

1. Submittal Schedule: The CONTRACTOR shall submit for approval a control room layout drawing **complete within 90 calendar days** after the date of Notice to Proceed is given to the CONTRACTOR.
2. Submittal Content: The control room layout shall be dimensioned and to scale. It shall show all the desk chairs and other furniture and, if applicable, uninterruptible power supplies and server panels. Electrical and communication panels and conduits for power, signal, communication and network(s) shall also be shown.

J. Display and Report Submittals:

1. Submittal Schedule:
 - a. After all Software Submittals have been approved by the ENGINEER, but **30 calendar days prior to the requisite Graphics and Report Meetings**, the CONTRACTOR shall submit a minimum of three (3) sets of the graphic displays, trend displays, and periodic reports for review by the ENGINEER and OWNER.
 - b. A minimum of three (3) sets of submittals shall be submitted for review by the ENGINEER and the OWNER. This submittal shall be prepared and submitted 30 calendar days after the requisite Graphics and Report Meetings specified in Section 40 68 00 – PLC-Based Control System Software.
2. Submittal Contents:
 - a. The CONTRACTOR shall refer to the specified Graphic meetings No.1 and 2 in Section 40 68 00 - PLC-Based Control System Software.
 - b. Displays: All workstation displays (graphics and trends) submittals shall be in full color as they will appear on the monitor. Locations for process data shall be clearly identified either through the use of simulated data or by showing variables on the displays and providing a reference list describing those variables. All dynamic points shall be identified by tag number as a minimum and their operation shall be described on separate sheets (color change, symbol change, etc.).
 - c. Reports: Sample reports of each type shall be submitted in the format established in the Graphics Meeting. The reports shall use simulated data.

K. Communication Field Survey and Test Procedure Submittal

1. Submittal Schedule: The CONTRACTOR shall submit for approval a comprehensive communication field survey and test procedure **complete within 120 calendar days** after the date of Notice to proceed is given to the CONTRACTOR.
2. Submittal Contents: The submittal shall include a communication survey and proposed tests with example(s) of proposed forms and checklist. The radio survey and test procedure shall result in generating as a minimum, the required parameters and data (e.g. antenna height, fade margin, receive signal strength, path quality, etc.) in order to implement a reliable communication system as specified in Division 27. "Communication System."

L. Communication Field Test Results and Report Submittal

1. Submittal Schedule: The CONTRACTOR shall submit for approval the communication field test results and report **complete within 14 calendar days** after receipt of the approved communication test procedure.
2. Submittal Contents: The report shall present the results of the communication survey and test and the filled up forms.

M. Factory Test Procedure Submittal:

1. Submittal Schedule: The CONTRACTOR shall submit for approval a comprehensive factory acceptance test (FAT) procedure **complete within 180 calendar days** after the date of Notice to Proceed is given to the CONTRACTOR, but not later than **60 calendar days** prior to the Factory Acceptance Test date.
2. Submittal Contents:
 - a. The CONTRACTOR shall develop and submit a factory test procedures to show that the integrated system hardware and software is fully operational and in compliance with the requirements of the Contract Documents. (Also see "Quality Assurance" paragraph in this Section and Section 40 68 00 – PLC-Based Control System Software.
 - b. The FAT procedures shall include the following tests to be conducted:
 - 1) Hardware review and inventory
 - 2) Central computer system(s) start-up
 - 3) Security
 - 4) Navigation and operator's commands
 - 5) Database definition and configuration
 - 6) Graphic displays and editing function
 - 7) Monitoring and alarm features and functions
 - 8) Trending functions
 - 9) Reports and report system functions
 - 10) Redundancy and backup
 - 11) Network Communication and access from all the network nodes
 - 12) Remote access from laptops
 - 13) PLC functionality – I/O processing
 - 14) Site/facility/Process PLC and HMI operation including pump and valve control

- c. Procedure Format: The test procedure shall have a table of contents and each procedure shall be provided on a separate sheet or sheets. The following shall be provided for each procedure:
- 1) Test number
 - 2) The purpose of the test
 - 3) The procedure
 - 4) The expected result
 - 5) Space to indicate "Pass" and "Fail" and explanation
 - 6) Space for sign-off Signature for the Contractor/System Supplier, the ENGINEER, the OWNER, and DATE
 - 7) Space to provide comments and punch list items

N. Startup and Commissioning Submittals

1. Submittal Schedule: The CONTRACTOR shall submit for approval a proposed procedure to be followed during startup and commissioning of the PCIS and its components **complete within 270 calendar days** after the date of Notice to Proceed is given to the CONTRACTOR, but not later than **60 calendar days** prior to the Factory Acceptance Test date. The CONTRACTOR shall submit the proposed.
2. Preliminary Submittal: Outlines of the specific procedures and examples of proposed forms and checklists.
3. Detailed Submittal: After approval of the Preliminary Submittal, the CONTRACTOR shall submit the proposed detailed procedures, forms, and checklists. This submittal shall include a statement of objectives with the test procedures.

O. Training Plan and Training Manual Submittals:

1. Submittal Schedule: The CONTRACTOR shall submit for approval a training plan and a training manual submittal **complete and within 270 calendar days** after the date of Notice to Proceed is given to the CONTRACTOR, but no later than **60 calendar days** prior to start of the first training session.
2. Submittal Contents: The Training submittal shall consist of two parts:
 - a. Training Plan, which shall include:
 - 1) Schedule of training courses including dates, durations, and locations of each class. Number of times each class will be offered, if applicable and the number of people expected in each class.
 - 2) List of courses and lessons and who will conduct them
 - 3) Resumes of the instructors who will actually conduct the training classes. The CONTRACTOR shall identify in the submittal the courses and lessons that will be performed by the equipment manufacturer.

- 4) List of material used for the training, which shall include the Technical Manuals for the PCIS.
- b. Training Manual
 - 1) Training subjects' syllabus and associated lesson plans. The training subjects are listed in Part 3 "Execution" of this Section. If, in the opinion of the System Supplier, additional subjects that are not listed and are pertinent to the training and will benefit the OWNER's staff, these subjects shall also be included in the training manuals and taught in the class.

1.6 CLOSEOUT SUBMITTALS

A. Technical Manuals Submittal

1. Submittal Schedule:

- a. The CONTRACTOR shall submit for approval Technical Manuals for the PCIS: Initial set shall be submitted **complete and within 270 days months** after the date of Notice to Proceed is given to the CONTRACTOR. But at least **60 days** prior to the starts of the OWNER's training.
- b. Each set shall consist of one (1) or more volumes and provided in PDF on a CD.

2. Submittal Contents:

- a. Information in the Technical Manual shall be based upon the approved Shop Drawing submittals as modified for conditions encountered in the field during the WORK. The Technical Manuals shall therefore contain the as-built drawings and information.
- b. The Technical Manuals shall include installation, connection, operating, calibration, set points (e.g., pressure, pump control, time delays, etc.) adjustment, test, troubleshooting, maintenance, and overhaul instructions in complete detail.
- c. The Manuals shall have the following material organized in volumes and divided by subject and tabs The Technical Manual shall have the following organization for each process (the number and the enumeration of the sections shall be project specific):
 - 1) Section A - Process and Instrumentation Diagrams (as built copy)
 - 2) Section B - System Architecture and Communication System Block Diagram(s)
 - 3) Section C - Wiring Diagrams. A separate set of drawings shall be provided for each site. Each set shall be arranged in a separate tab (drawings shall also be provided in PDF).
 - 4) Section D – Functional design report. It shall include a copy of the site graphic display(s) and description how the site is controlled and any

special control strategies specific for each site. Special control functions in the server shall also be included. Calibration, set points (e.g., pressure, pump control, time delays, etc.) shall also be included.

- 5) Section E - Instrument Data Sheets and corresponding manufacturer's data sheet/catalog cuts/brochure that was used in the hardware submittal and the operation and maintenance/user manual.
 - 6) Section F - Calibration Documentation
 - 7) Section G – Communication survey and test results
 - 8) Section H - Loop, Commissioning and Performance Test Results
- d. Software Manual: This manual shall be devoted exclusively to the control system software and the PLC programming. In addition to the requirements specified in Section entitled Contractor Submittal, this manual shall contain complete documentation of the software programs provided, including listings, database (CD), communication protocol(s), annotated PLC programs, and all as necessary to maintain, troubleshoot, modify, or update the all the software systems such as application software and PLCs. It shall also include:
- 1) All program manuals and CDs supplied by the manufacturers with the standard software packages the source code of all high level program language which is specifically created by the CONTRACTOR for this project.
 - 2) All PLC program and workstation configuration program files stored on labeled CDs. The PLC program and workstation configuration files on CDs shall also be updated as required if any changes or corrections are required in this programming prior to project completion.

1.7 MAINTENANCE MATERIAL SUBMITTALS

- A. The CONTRACTOR shall provide the specified spare parts and tools. In addition, The ENGINEER and the OWNER will select from the priced list of "Additional Recommended Spare Parts" in the Hardware Equipment Submittal. The CONTRACTOR shall furnish these parts and will be paid for them from the corresponding allowance item in the Bid. The total price will not exceed the amount of the allowance item.
- B. The CONTRACTOR shall furnish a priced list of special tools required to calibrate and maintain the instrumentation provided from which the ENGINEER or the OWNER will select the needed tools. After approval the CONTRACTOR shall furnish tools on that list. The cost of these tools will be included in the allowance.
- C. The CONTRACTOR shall furnish one (1) portable instrument loop calibrator with current simulator with charger and carrying case. The calibrator shall be **Fluke 709H series**, Ametek AccuPro Calibrator CL-9005, or equal.

1.8 QUALITY ASSURANCE

- A. Factory Acceptance Tests (FAT):

1. Prior to shipment, the PCIS including all panels, integrated SCADA system, PLCs, peripherals, communications equipment, etc. provided under this Division, shall be assembled, connected, and all software loaded for a full functional factory acceptance test (FAT) of the integrated system. Existing equipment is not required to be included in this test.
 2. In preparation for the FAT, the CONTRACTOR shall check, troubleshoot, debug and test the PCIS prior to arrival of the ENGINEER in order for the PCIS to be ready for the FAT, minimize testing time, and minimize re-testing during the visit. Similar testing shall be performed even if the ENGINEER chooses not to witness the FAT.
 3. The CONTRACTOR shall allow the ENGINEER and OWNER to inspect the PCIS and witness the functional testing of the system at the site of assembly and integration of the system.
 4. A minimum of 21 Days notification shall be given to the ENGINEER prior to testing. No shipments shall be made without the ENGINEER's approval. A successful completion of the test is a prerequisite to the shipment of the system.
 5. The factory test will be witnessed by the ENGINEER and the OWNER. The CONTRACTOR shall pay and provide for travel, food, and lodging for all the test witnesses.
 6. The factory acceptance test shall be conducted at the place where the system was engineered, fabricated, assembled, and programmed.
 7. It is considered reasonable that once scheduled, the system will be ready for the test and the test will be successfully completed in one session. If during the test, at the opinion of the ENGINEER and in accordance with the test procedure, the system is not ready for the test or has failed, and the ENGINEER and the OWNER must extend their stay or leave and arrive at another date, the OWNER reserves the right to withhold monies due to the CONTRACTOR to cover additional costs of the ENGINEER's time, travel, food, and lodging and associated project cost.
 8. During the factory acceptance test, the CONTRACTOR's Project Manager and software engineers (HMI application software and PLC programming) who worked on the PCIS shall be available on the premises where the test is being conducted for explanation, demonstration or corrections.
 9. After the successful completion of the test, the ENGINEER will generate a punch list. The list may include items that must be corrected or addressed prior to the shipment of the system, and/or items that must be corrected later in the field during installation and startup.
- B. Field Tests: The CONTRACTOR's attention is directed to the Article "EXECUTION" of this Section which delineates all the tests that are required to be performed in the field in order to demonstrate compliance with the Contract Documents.
- C. The CONTRACTOR shall provide and assign to the OWNER all user software and hardware licenses. Computer and software system shall be purchased on behalf of the OWNER who shall also be designated as the licensee. Each software package shall be provided with a "Site License" or with as many licenses as a "Site License" includes (site is defined as the name of the OWNER). The CONTRACTOR shall include in the bid price all license fees.

- D. The CONTRACTOR shall provide the proper number of software licenses for all the servers, workstations, and laptops to provide concurrent and simultaneous user operation.
- E. Prior to final acceptance of the PCIS System and related equipment, the CONTRACTOR shall propose and present in writing to the OWNER a one-year maintenance contract and quotation which will become effective upon the expiration of the warranty. The maintenance contract is an option that the OWNER may purchase from the System Supplier. The contract shall offer different maintenance, site visit and help-desk with options each with its respective cost.

1.9 FIELD SITE CONDITIONS

- A. The PCIS shall be designed and constructed for satisfactory operation and long, low maintenance service under the following environmental conditions:
 - 1. Water treatment facility
- B. Site Equipment:
 - 1. Ambient temperature range: -18° through 60° C
 - 2. Thermal shock: 1.0° (1.8° F) per minute maximum
 - 3. Relative humidity: 95 percent maximum non-condensing

1.10 WARRANTY

- A. All parts, material labor, travel, subsistence, or other expenses incurred in providing services and service visits during the warranty period shall be borne by the CONTRACTOR under the guarantee specified in Division 1. Equipment, software, and materials that do not achieve their intended purpose shall be replaced by the CONTRACTOR to attain compliance, at no additional cost to the OWNER.
- B. Extended Period for Correction of Defects: The CONTRACTOR shall correct defects in the PCIS upon notification from the OWNER within 2 years from the date of Substantial Completion. Corrections shall be completed within 5 Days after notification.
- C. The performance of the servers and workstations hardware shall be guaranteed (repair of parts and labor at the owner's site including travel expenses) for a period of three (3) years following the date of completion and formal acceptance of the work (next business day on-site service).
- D. Software Upgrades: During the warrantee period, the CONTRACTOR shall furnish and install at no additional cost to the OWNER any application software upgrades published applicable to OWNER's applications and compatible with OWNER's hardware and operating system.

PART 2 -- PRODUCTS

2.1 GENERAL

- A. **Standard and Current Technology:** All PCIS hardware, software, materials, and equipment furnished under this contract shall be new, free from defects, and shall be standard products and technology produced by manufacturers regularly engaged in the manufacture of these products. Meters, instruments, and other components shall be the most recent field-proven models marketed by their manufacturers at the time of submittal of the Shop Drawings unless otherwise required to match existing equipment.

The CONTRACTOR shall submit a Substitute Item Request Form in case of discontinued or upgraded product or other cases where changing technology requires changes in equipment or software.

- B. **Adverse Environmental Impact:** No component of an instrumentation system shall contain liquid mercury.
- C. **Hardware Commonality and Modularity:** Instruments which utilize a common measurement principle shall be furnished by a single manufacturer. Panel mounted instruments shall have matching style and general appearance. Instruments performing similar functions shall be of the same type, model, or class, and shall be from a single manufacturer. All equipment shall be of modular design to facilitate interchangeability of parts to assure ease of servicing and expandability.
- D. **Instrument and Loop Power:** Power requirements and input/output connections for components shall be verified. Power for transmitted signals shall, in general, originate in and be supplied by the control panel devices. The use of "2 wire" transmitters is preferred, and use of "4 wire" transmitters shall be minimized. Individual loop or redundant power supplies shall be provided as specified and/or as required by the manufacturer's instrument load characteristics to ensure sufficient power to each loop component. Power supplies shall be mounted within control panels or in the field at the point of application.
- E. **Loop Isolators and Converters:** The CONTRACTOR is responsible to resolve any signal level incompatibilities where required.
- F. **Signal Levels:** Analog measurements and control signals shall be as indicated herein, and unless otherwise indicated, shall vary in direct linear proportion to the measured variable. Electrical signals outside control panels shall be 4 to 20 milliamperes DC except as indicated. Signals within enclosures may be 1 to 5 volts DC. Electric signals shall be electrically or optically isolated from other signals. Pneumatic signals shall be 3 to 15 psig with 3 psig equal to 0 percent and 15 psig equal to 100 percent.
- G. **Alternative Equipment and Methods:** Equipment or methods requiring redesign of any project details are not acceptable without prior written approval of the ENGINEER through the "or equal" process of Section 016000 - Products, Materials, Equipment, and Substitutions. Any proposal for approval of alternative equipment or methods shall include evidence of improved performance, operational advantage, and maintenance enhancement over the equipment or method indicated, or shall include evidence that an indicated component is not available.

PART 3 -- EXECUTION

3.1 EXAMINATION

- A. Shipping: After completion of shop assembly, factory test, and approval, the tested PCIS equipment, cabinets, panels, and computer hardware shall be packed in protective crates and enclosed in heavy duty polyethylene envelopes or secured sheeting to provide complete protection from damage, dust, and moisture. Dehumidifiers shall be placed inside the polyethylene coverings. The equipment shall then be skid-mounted for final transport. Lifting rings shall be provided for moving without removing protective covering. Boxed weight shall be shown on shipping tags together with instructions for unloading, transporting, storing, and handling at the Site.
- B. Special Instructions: Special instructions for proper field handling, storage, and installation required by the manufacturer shall be securely attached to each piece of equipment prior to packaging and shipment.
- C. Tagging: A permanent stainless steel or other non-corrosive material tag marked with the instrument or equipment tag number shall be provided on each piece of equipment in the PCIS. Identification shall be prominently displayed on the outside of the package.
- D. Storage: It is the CONTRACTOR's responsibility to assure proper handling and on-site storage of instrumentation and control equipment in accordance with the System Supplier's recommendations. All equipment and materials delivered to the jobsite shall be stored in a location which will not interfere with the operations of other contractors or the OWNER. Equipment shall not be stored outdoors. Storage and handling will be performed in manners which will afford maximum protection to the equipment and materials.
- E. Equipment shall be stored in dry shelters, including in-line equipment, and shall be adequately protected against mechanical damage. If any apparatus has been damaged, such damage shall be repaired by the CONTRACTOR. If any apparatus has been subject to possible damage by water, it shall be thoroughly dried out and put through tests as directed by the ENGINEER. If such tests reveal defects, the equipment shall be replaced.

3.2 INSTALLATION

A. General

- 1. All systems and instrumentation, including instrumentation furnished under other Divisions, shall be installed, connected calibrated, tested, started, and placed into operation in accordance with CONTRACT documents under Division 40 and the manufacturers' instructions. The installation shall be coordinated with the ENGINEER and the OWNER. This shall include final integration in concert with equipment specified and provided by others.
- 2. The CONTRACTOR shall employ installers who are skilled and experienced in the installation and connection of all PCIS equipment.
- 3. The CONTRACTOR shall furnish the services of an on-site engineer to supervise and coordinate installation, adjustment, testing, and start-up of the PCIS. The engineer shall be present during the total period required to affect a complete operating system. A team of engineering personnel shall be at the site for 80 hours

to check equipment, perform the tests indicated in this Section, and furnish startup services.

4. Equipment Locations: The monitoring and control system configurations indicated in the contract documents are diagrammatic. The locations of equipment are approximate unless dimensioned. The exact locations and routing of wiring and cables shall be governed by structural conditions and physical interferences and by the location of electrical terminations on equipment. Equipment shall be located and installed so that it will be readily accessible for operation and maintenance. Where job conditions require reasonable changes in approximated locations and arrangements, or when the OWNER exercises the right to require changes in location of equipment which do not impact material quantities or cause material rework, the CONTRACTOR shall make such changes without additional cost to the OWNER.
5. The CONTRACTOR shall review the existing site conditions and examine all shop drawings for the various items of equipment in order to determine exact routing and final terminations for all wiring and cables.
6. The Contract Documents identify conduits and instruments required to make a complete PCIS. The CONTRACTOR shall be responsible for providing any reasonable additional or different type connections as required by parts of the PCIS' specific installation requirements, or as practical.

B. Conduit, Cables, and Field Wiring

1. Conduits, process equipment control wiring, 4 to 20 mA signal circuits, signal wiring to field instruments and to control panels, SCADA PLC input and output wiring, and other field wiring and cables shall be provided under Division 26 and without delay to the WORK of Division 40.
2. SCADA PLC equipment cables and communication networks shall be provided under Division 40, but the installation in the field shall be under Division 26.
3. Terminations and wire identification inside PCIS equipment and panels furnished under this or any other Division shall be provided under Division 40.
4. The CONTRACTOR shall supervise and coordinate installation and termination and identification of field signals, power, and utilities associated with the PCIS. Resolve signal, power, or functional incompatibilities between the PCIS and new and existing interfacing devices.

C. Installation and Connections:

1. Instruments, control panels, and equipment shall be anchored by methods that comply with seismic requirements applicable to the Site. Appropriate mounting stands and bracket materials and workmanship shall be provided and shall comply with requirements of the Contract Documents.
2. Existing Instruments that are to be removed and reinstalled shall be cleaned, reconditioned, and recalibrated by an authorized service facility of the instrument manufacturer. The CONTRACTOR shall provide certification of this WORK prior to reinstallation of each instrument.

3. The Contract Documents show necessary conduit and instruments required to make a complete instrumentation. The CONTRACTOR shall be responsible for providing any additional or different type connections as required by the instruments and specific installation requirements. Such additions and such changes, including the proposed method of installation, shall be submitted to the ENGINEER for approval prior to commencing that WORK. Such changes shall not be a basis of claims for extra WORK or delay.
4. Field Connection Panels and Interface Terminal Blocks: In cases where field I/O wiring has to be extended to a control panel or from enclosures or devices that are removed, the CONTRACTOR shall provide separate enclosures or junction boxes with interface terminal blocks that will serve as a field connection panel (FCP). The FCP and the terminal block shall be shown on the project-wide wiring diagrams.
5. Conduits and/or raceways in building interior locations shall be surface mounted on walls or ceilings wherever possible and run perpendicular and parallel to building lines. Conduits shall not be routed on floors in areas subject to foot traffic. In exterior locations conduit shall be routed below grade.
6. Wires and cables shall be arranged in a neat manner and securely supported in cable groups and connected from terminal to terminal without splices unless specifically approved by the ENGINEER. Wiring shall be protected from sharp edges and corners.
7. Signal and low voltage wiring shall be run in a separate conduit from power and 120-volt control wiring.
8. Field wiring shall terminate at terminal blocks in the control panel. Field wiring shall not be wired directly to equipment in the control panel except communication and specialty cables that must be wired directly to their respective equipment.
9. Power and signal wires shall be terminated with crimped type lugs.
10. Wires shall be marked clearly with an identification wire number labels that are of a permanent nature. Computer system equipment cables shall be identified and marked for their location at each end of the cable. Computers and peripheral equipment connections/ports shall also be identified as to what cable is connected to its port location.
11. Connectors shall be, as a minimum, water tight.
12. Sensing Lines and Tubing:
 - a. Instrument process sensing lines shall be installed in conduit under Section 260000 - Electrical General Provisions and in a manner similar to the conduits. Individual tubes shall run parallel and near the surfaces from which they are supported. Supports shall be used at intervals of not more than 3-feet of rigid tubing.
 - b. Bends shall be formed to uniform radii with the proper tool without deforming or thinning the walls of the tubing. Plastic clips shall be used to hold individual plastic tubes parallel. Ends of tubing shall be square cut and cleaned before being inserted in the fittings. Bulkhead fittings shall be provided at panels requiring pipe or tubing entries.

13. Flexible cables and capillary tubing shall be installed in flexible conduits. The lengths shall be sufficient to withdraw the element for periodic maintenance.
14. Differential pressure elements shall have 3 valve manifolds.
15. The CONTRACTOR shall verify the correctness of each installation, including polarity of electric power and signal connections. The CONTRACTOR shall certify in writing all discrepancies have been corrected for each loop or system checked out. In addition, the CONTRACTOR shall make sure process connections are free of leaks.

3.3 FIELD QUALITY CONTROL

A. General:

1. Devices provided under Division 40 shall be initially calibrated by the manufacturer at the manufacturer's facility prior to shipment. Following installation, the devices shall be field calibrated according to the manufacturer's recommended procedures to verify operational readiness and ability to meet the indicated functional and tolerance requirements.
2. Each instrument shall be field tested, inspected, and adjusted to the indicated performance requirement in accordance its manufacturer's specifications and instructions. Any instrument which fails to meet any contract requirement, or, in the absence of a contract requirement, any published manufacturer performance specification for functional and operational parameters, shall be repaired or replaced, at the discretion of the ENGINEER.

B. Calibration Points: During bench and field calibration each instrument shall be calibrated at least at 0, 25, 50, 75, and 100 percent of span using test instruments to simulate inputs and outputs. The test instruments shall have accuracies traceable to National Institute of Standards and Testing.

C. Bench Calibration: Instruments that have been bench-calibrated by the manufacturer shall be verified in the field after installation to determine whether any of the calibrations are in need of adjustment.

D. Field Calibration: Instruments which were not bench-calibrated shall be calibrated in the field to insure proper operation in accordance with the instrument loop diagrams or specification data sheets.

E. Analyzer Calibration: Each analyzer system shall be calibrated and tested as a workable system after installation. Testing procedures shall be directed by the manufacturers' technical representatives. Samples and sample gases shall be furnished by the manufacturers.

F. Calibration Sheets: Each instrument calibration sheet shall provide the following information and a space for sign-off on individual items and on the completed unit:

1. Project name
2. Loop number and site or process name and number
3. Tag number

4. Manufacturer
 5. Model number
 6. Serial number
 7. Calibration range
 8. Calibration data: Input, output, and error at 0 percent, 50 percent, and 100 percent of span
 9. Switch setting, contact action, and dead-band for discrete elements
 10. Space for comments
 11. Space for sign-off by System Supplier and when applicable by the manufacturer and date
 12. Test equipment used and associated serial numbers
- G. Calibration Tags: A calibration and testing tag shall be attached to each piece of equipment or system at a location determined by the ENGINEER. The CONTRACTOR shall have the System Supplier sign the calibration sheet when calibration is complete. The ENGINEER will sign the calibration sheet when the calibration and testing has been accepted.
- H. Loop Testing: The Contractor shall test newly installed loops for continuity and functionality. The up-to-date wiring diagrams shall be used as reference. The ENGINEER and/or the OWNER shall witness the loop testing.
- I. The CONTRACTOR shall notify the ENGINEER of scheduled tests minimum of [[[30]]] calendar days prior to the estimated completion date of installation and wiring of the PCIS. After the ENGINEER's review of the submitted loop diagrams for correctness and compliance with the specifications, loop testing shall proceed. The loop testing shall be witnessed by the ENGINEER and/or the OWNER.
- J. Control Valve Tests: Control valves, cylinders, drives and connecting linkages shall be stroked from the operator interface units as well as local control devices and adjusted to verify proper control action, hand switch action, limit switch settings, torque settings, remote control actions, and remote feedback of valve status and position. Control valve actions and positioner settings shall be checked with the valves in place to insure that no changes have occurred since the bench calibration.
- K. Interlocks: Hardware and software interlocks between the instrumentation and the motor control circuits, control circuits of variable-speed controllers, and packaged equipment controls shall be checked to the maximum extent possible.
- L. Loop Validation:
1. Control loops shall be checked under simulated operating conditions by impressing input signals at the primary control elements and observing appropriate responses of the respective control and monitoring elements, final control elements, and the HMI displays associated with the SCADA PLC. Actual signals shall be used wherever available. Following any necessary corrections, the loops shall be retested.

2. Accuracy tolerances for each analog network are defined as the root-mean-square (RMS) summation of individual component accuracy requirements. Individual component accuracy requirements shall be as indicated by contract requirements or by published manufacturer accuracy specifications, whenever contract accuracy requirements are not indicated. Each analog loop shall be tested by applying simulated analog or discrete inputs to the first element of an analog loop. For loops which incorporate analog elements, simulated sensor inputs corresponding to 0, 25, 50, 75, and 100 percent of span shall be applied, and the resulting element outputs monitored to verify compliance to calculated RMS summation accuracy tolerance requirements. Continuously variable analog inputs shall be applied to verify the proper operation and setting of discrete devices. Provisional settings shall be made on controllers and alarms during analog loop tests. Analog loop test data, including calculated RMS summation system accuracy tolerance, shall be documented by the CONTRACTOR on the loop validation sheets. The validation sheets shall be included in the O&M Manuals.

M. Loop Validation and Certification Sheets:

1. Loop Validation: The CONTRACTOR shall prepare loop validation sheets for each loop covering each active instrumentation and control device except simple hand switches and lights. Loop validation sheets shall form the basis for operational tests and documentation. Each loop validation sheet shall cite the following information and shall provide spaces for sign-off on individual items and on the complete loop by the System Supplier:
 - a. Project name
 - b. Loop number
 - c. Tag number, description, manufacturer, and model number for each element
 - d. Installation bulletin number
 - e. Specification sheet number
 - f. Loop description number
 - g. Adjustment check
 - h. Space for comments
 - i. Space for loop sign-off by the System Supplier and date
 - j. Space for ENGINEER witness signature and date
2. Loop Certification: A certified copy of each loop test validation sheet signed by the System Supplier, the ENGINEER or the ENGINEER's representative as a witness, with test data entered, shall be submitted to the ENGINEER together with a clear and unequivocal statement that the loops have been tested and the instrumentation in the loop has been successfully calibrated, inspected, and tested.

N. Manufacturer's Services

1. The CONTRACTOR shall provide jobsite visits and services of a manufacturer's technical field representative for supervision of the following:

- a. Oversee installation: Supervise installation and connection of all instruments, elements, and components of every system, including connection of instrument signals to primary measurement elements and to final control elements such as VFD, smart starters, pumps, valves, engines and chemical feeders
 - b. Verify that installed instrument and software meet manufacturer's recommendations
 - c. Certify installation and reconfirm manufacturer's accuracy statement
 - d. Oversee loop testing, prepare loop validation sheets, and certify loop testing
 - e. Certify when testing is completed.
 - f. Training the OWNER's personnel
2. Manufacturer's services shall be furnished for the following equipment:

3.4 PRE-COMMISSIONING

A. General:

1. Pre-commissioning, which is defined in Section 017500 – Equipment Testing and Plant Startup, is basically the demonstration of proper operation of every part in the PCIS with process equipment operating over full operating ranges under conditions as closely resembling actual operating conditions as possible. All systems shall be exercised through field operational tests, as a complete PCIS in accordance with the approved test procedures and in the presence of the ENGINEER and/or the OWNER.
2. Pre-commissioning shall commence after completion and acceptance of continuity tests, calibration tests and loop tests, and inspections have demonstrated that the instrumentation and control system complies with contract requirements.
3. Pre-commissioning Procedures and Documentation: Pre-commissioning and test activities shall follow detailed test procedures and check lists accepted by the ENGINEER. Test data shall be acquired using equipment as required and shall be recorded on test forms accepted by the ENGINEER, which include calculated tolerance limits for each step. Completion of system pre-commissioning and test activities shall be documented by a certified report, including test forms with test data entered, delivered to the ENGINEER with a clear and unequivocal statement that system pre-commissioning and test requirements have been satisfied. The result of the testing shall also include a punch list developed by the ENGINEER.
4. The burden of proof of conformance of the system to specified functions and performance is on the CONTRACTOR. Tests that fail to demonstrate the required operation shall be repeated in their entirety or continued after corrective action has been completed at the discretion of the ENGINEER.
5. The CONTRACTOR shall supply necessary test equipment and technical personnel if called upon to prove accuracy and/or performance, at no separate additional cost to the OWNER, wherever the OWNER or ENGINEER has reasonable doubt or evidence of malfunction or poor performance appears.

6. The CONTRACTOR shall coordinate the scheduling of tests among all parties involved so that the tests may proceed without delays or disruption by uncompleted work. Field operational and functional testing must be successfully completed prior to the start of the 30-day final acceptance test.

B. Operational Validation:

1. Where feasible, system pre-commissioning activities shall include the use of the actual process to establish service conditions that simulate, to the greatest extent possible, normal final control element operating conditions in terms of applied process loads, operating ranges, and environmental conditions. Final control elements, PLCs, control panels, and ancillary equipment shall be tested under startup and steady state operating conditions to verify that proper and stable control is achieved using motor control center and local field mounted control circuits. Hardwired and software control circuit interlocks and alarms shall be operational.
2. The control of final control elements and ancillary equipment shall be tested using both manual and automatic (where provided) control circuits. The stable steady state operation of final control elements running under the control of process controllers shall be assured by adjusting the controllers as required to eliminate oscillatory final control element operation. The transient stability of final control elements operating under the control of controllers shall be verified by applying control signal disturbances, monitoring the amplitude and decay rate of control parameter oscillations (if any), and making necessary controller adjustments as required to eliminate excessive oscillatory amplitudes and decay rates.
3. Pre-commissioning shall also include the testing of remote sites to verify compliance with all functional requirements and communication specified. The testing shall include manual and automatic control modes, fail-safe and backup control modes, and PLC interlocks and control strategies provided by the System Supplier.

- C. Loop and Equipment Tuning: Controllers incorporating proportional, integral and/or derivative control circuits shall be optimally tuned, experimentally, by applying control signal disturbances and adjusting the gain, reset, or rate settings as required to achieve a proper response. Measured final control element variable position/speed set point settings shall be compared to measured final control element position/speed values at 0, 25, 50, 75, and 100 percent of span and the results checked against indicated accuracy tolerances.

- D. Pre-commissioning Validation Sheets: Pre-commissioning shall be documented on test forms as follows:

1. The validation form, which shall include:
 - a. Project name
 - b. Loop number
 - c. Loop and function description
 - d. Tag number, description, manufacturer, and data sheet number for each component.
 - e. Pre-Commissioning Certification - A statement certifying that the contract requirements have been met. It shall also include a listing of instrumentation

and control system maintenance and repair activities conducted during the pre-commissioning testing. Acceptance of the instrumentation and control system testing must be provided in writing by the ENGINEER before the performance testing may begin. Final acceptance of the control system shall be based upon plant completion as stated in the General Conditions.

- f. Space for sign-off and date by the CONTRACTOR, the System Supplier, and the ENGINEER.

3.5 COMMISSIONING

- A. Commissioning is the verification that the complete WORK functions on an extended basis are in full conformance with the Contract requirements.
- B. As part of the commissioning, the entire PCIS shall operate continuously without failure for 30 consecutive days without failure (see test details below), thus extending its operation test longer than the commissioning period specified in Section 017500.

3.6 STARTUP OPERATION

- A. General: Startup is defined as testing, demonstrations, and other activities as required to achieve Substantial Completion. Pre-commissioning and commissioning activities, manufacturer's services, certifications of readiness for testing, and troubleshooting, checkout, and shakedown activities must be completed before startup activities begin.
- B. When all equipment and systems have been assessed by the CONTRACTOR to have been successfully carried through complete operational and functional tests with not less than a minimum of simulation, and the ENGINEER concurs in this assessment, system startup by the OWNER'S operating personnel can follow.
- C. Each facility, process, or site startup shall be performed in accordance with the approved test procedures.
- D. Scheduling of startup shall be coordinated by the CONTRACTOR among all parties involved so that the tests may proceed without delays or disruption by uncompleted work. System startup and training and instruction of the OWNER's personnel must be completed a minimum of seven (7) days prior to the final acceptance test.

1. Troubleshooting and Corrections

- a. The Contractor shall participate in all start-up activities. If problems occur, the CONTRACTOR and the System Supplier shall jointly participate in the diagnosis wiring, control interface, hardware and software problems and correct deficiencies. The Contractor shall be responsible and bear all expenses to diagnose and correct all the deficiencies for work and equipment furnished under this CONTRACT.
- b. Existing Instruments, Wiring and Interface: As specified above, prior to start of the WORK the CONTRACTOR shall request the OWNER to demonstrate that all existing equipment and software that is to be reused or interfaced with in this project works properly for the intended function. Consequently, if during the calibration, testing or start up the Contractor and/or the System Supplier encounters problems with existing instruments, hardware, wiring, or software that have been demonstrated to work, the CONTRACTOR shall notify the Engineer and the OWNER. In this case, the CONTRACTOR, the System

Supplier and the Owner's representative shall jointly participate in the diagnosis of the problem. The course of action how to correct the deficiency shall be determined jointly by the OWNER, the Engineer and the CONTRACTOR/System Supplier. The CONTRACTOR shall be compensated for correcting the deficiencies or replacing the equipment.

- c. If a problem is found to be a result of the CONTRACTOR's workmanship or equipment and work furnished under this CONTRACT, the CONTRACTOR shall be responsible and bear the expenses for correcting the deficiencies.

3.7 FINAL ACCEPTANCE TEST (COMMISSIONING)

- A. After the pre-commissioning, functional tests and startup have been completed, the CONTRACTOR shall submit a report/letter states that CONTRACT requirements have been met and the PCIS is ready for the Final Acceptance Test.
- B. The entire PCIS shall go through a final 30-day acceptance test. For the purpose of this CONTRACT, the terms "Final Acceptance Test" and "Final Performance Test" are synonymous and are used interchangeably. The 30-day test must be successfully completed prior to the date of and as a condition to substantial completion of the entire project WORK. During the testing period, all system functions shall be exercised, and any system interruption and accompanying component, subsystem, software, or program failure shall be logged for cause of failure, as well as time of occurrence and duration of each failure.
- C. In addition to the requirements of Section 017500, the CONTRACTOR shall furnish support staff as required to operate the system and to satisfy the repair or replacement requirements. The CONTRACTOR shall also provide a competently programmer on call during all normal working days and hours from the start of the acceptance test until final acceptance of the system. The on-call programmers shall be ready to respond within two hours of the notification of the problem.
- D. Testing: The entire PCIS shall be tested and shall include, but not limited to, the field instrumentation, control and PLC panels and PLC programs, application SCADA software, graphics and trends, reports, and the control and monitoring functions. Each system function, e.g., status report-backs, alarms, logs, and displays shall be exercised several times at a minimum, and in a manner which approximates "normal" system operation. At least two displays and reports shall be generated during the test.
- E. Failure During Testing: Failure of the system during the testing shall be considered as indicating that part of the PCIS does meet the requirements of the specifications and corrective action shall be required before restarting the acceptance test.

Failures shall be classified as either major or minor as follows, and it is at the discretion of the ENGINEER how to classify the failure:

- 1. Minor Failure: A minor failure would be a small and non-critical component failure which can be corrected by the OWNER's operators. This occurrence shall be logged, but shall not be reason enough for stopping the test and shall not be grounds for non-acceptance or –restart, provided that the function(s) can be provided by backup equipment and repairs can be made and equipment returned to service within one (1) working day.

However, should the same or similar component failure occur repeatedly, this may be considered as grounds for non-acceptance and termination of the test.

2. Major Failure: A major failure shall be considered to have occurred when a major component of the PCIS, subsystem, communication, or program fault causes a halt in operation of the system and/or when a technician's work is required to make a repair or to re-initiate operation of the system. A major failure shall cause termination of the acceptance test. When the causes of a major failure have been corrected, a new acceptance test shall be started.

- F. Technician Report: Each time a technician is required to respond to a malfunction in the PCIS he/she must complete a report which shall include details concerning the nature of the complaint or malfunction and the resulting repair action required and taken. If a malfunction occurs which clears itself or which the operator on duty is able to correct, no report shall be required (logged as specified above). Each report shall be submitted within 24 hours to the ENGINEER or its representative, and the OWNER.

3.8 CLOSEOUT ACTIVITIES

A. Training:

1. The CONTRACTOR shall train the OWNER'S personnel on the PCIS operation, maintenance, calibration, and repair of equipment provided under this Contract. The training shall be by qualified instructors. The training courses shall be given on-site to a minimum of four (4) people of the OWNER's personnel. All instruction, tools and training material shall be provided by the CONTRACTOR.
2. These courses shall be designed to provide the operations, maintenance and supervisory personnel with training in routine and preventive maintenance of all the PCIS including instrumentation, communication, PLCs software, and HMI. The training course shall include instruction on the use of all maintenance equipment and special tools provided under the contract.
3. Instructions: The training shall be performed by qualified instructors. The training shall be performed by qualified representatives of the equipment manufacturers and shall be specific to each piece of equipment.
4. Training Manuals and Material: The CONTRACTOR shall use the approved Training syllabus and Training Manuals to develop training material. The training material shall be designed to provide the operations, maintenance and supervisory personnel with training in routine operation procedures, and preventive maintenance and troubleshooting of the PCIS, PLCs and the computer monitoring and control systems.
5. Schedule: Training shall be performed on-site during the calibration, loop and functional testing of the PCIS prior to the 30-day Final Acceptance Test. The training sessions shall be scheduled a minimum of 3 weeks in advance of when the courses are to be initiated. The ENGINEER will review the course outline for suitability and provide comments that shall be incorporated. Due to availability and scheduling of the OWNER's staff, the CONTRACTOR shall coordinate with the OWNER the schedule of the classes. The OWNER reserves the right to videotape the training sessions for later use. Due to possible limited availability of the OWNER's staff, the CONTRACTOR shall provide the number of identical courses/sessions of each of the following training courses as indicated, each up to four (4) people of the OWNER's staff.

6. Training Subjects, Duration, and Agenda: The training shall include operation and maintenance procedures, troubleshooting with necessary test equipment, and changing set points, and calibration for that specific piece of equipment. During the course, hands-on experience with the system equipment shall be provided. Maintenance classes shall stress troubleshooting, repair, calibration, and other technical aspects of the PCIS and the PLCs. Operator classes shall stress operational theory and use of the PCIS and the PLCs.
 - a. Field Instruments
 - 1) Duration – an average of two (2) hours per each type of instrument
 - 2) Subjects - installation, setup, configuration, maintenance, calibration, and troubleshooting:
 - a) Pressure transmitter
 - b) Level transmitter
 - c) Flow measuring device and transmitter
 - d) Analyzer – liquid and gas
 - e) Weather monitoring
 - f) Temperature transmitters
 - g) Power monitoring equipment
 - h) Vibration transmitter
 - i) Uninterruptible power supply (UPS)
7. PLC: The training of the following subject shall be performed by the CONTRACTOR and the PLC manufacturer as noted: Maintenance classes shall stress troubleshooting, repair, calibration, and other technical aspects of the PLC. Operator classes shall stress operational theory and use of the PLCs.
 - a. Duration – 40 instruction hours or a minimum of 8-hours per class of PLC training.
 - b. Subjects:
 - 1) PLC System Hardware and Programming Software - General Familiarity – by the PLC Manufacture.
 - 2) PLC programming I/O, ladder logic, registers, etc. (process/site specific) – by the CONTRACTOR
 - 3) Project specific operation and communication – by the CONTRACTOR
 - 4) Project specific PLC program troubleshooting – by the CONTRACTOR

- 5) PLC Hardware- Troubleshooting and Repair of PLCs _by the PLC manufacturer or by the CONTRACTOR if approved by the ENGINEER
8. Central computer system and HMI Development
 - a. Duration
 - 1) 8 hours for maintenance programmer
 - 2) 8 hours for development training system
 - b. Subjects
 - 1) HMI configuration.
 - 2) Report and trend generation
 - 3) Operator training
 - 4) Programmer training
 - 5) HMI graphics with emphasis on making changes and additions to reports and displays method to be used for scheduling and changing the scheduling of reports.
 - 6) Data base programming, adding or deleting analog and digital points adding future data base points. linking data base points to screen displays
 - 7) The CONTRACTOR shall provide two (2) identical courses/sessions of development system training. Each development training system training course shall be 16 hours for graphic displays and report generation applications.
 - 8) Integrating future PLCs into the SCADA system
 - 9) Historical backup and maintenance.
 - 10) Server redundancy, failure and switchover
 - 11) Diagnostics, troubleshooting, and related procedures
9. Communication System and Network
 - a. Duration – 8 hours
 - b. Subjects –
 - 1) Communication types and communication equipment – radio, cellular, etc.
 - 2) PLC communication hardware
 - 3) Network equipment and maintenance

- 4) Communication protocols
- 5) Wireless communication
- 6) Communication failure diagnosis/troubleshooting and repair

3.9 CRITERIA FOR SUBSTANTIAL COMPLETION

- A. For the purpose of this Section and all Division 40, the following conditions shall be fulfilled before the WORK is considered substantially complete:
1. Submittals have been completed and approved.
 2. The PCIS has been calibrated; loop tested, pre-commissioned, commissioned, and the startup completed.
 3. The OWNER's training has been performed.
 4. Spare parts and expendable supplies and test equipment have been delivered to the OWNER.
 5. The Final Acceptance Test has been successfully completed.
 6. Major punch-list items have been corrected.
 7. As built drawings in both hard copy and electronic format have been submitted. The as built drawings shall also include annotation of the PLC ladder logic program by providing a descriptive label for all relays and function blocks and functional description of each rung.
 8. Revisions to the Technical Manuals that may have resulted from the field tests have been made and reviewed.
 9. Debris associated with installation of instrumentation has been removed.
 10. Probes, elements, sample lines, transmitters, tubing, and enclosures have been cleaned and are in like-new condition.

END OF SECTION

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MARCH 2024
PROCESS CONTROL SYSTEM INSTRUMENT LIST
1 OF 1

BOOSTER PUMP STATION PLC

DI		48	DSDI	6
DO		3	DSDO	0
AI		11	DSAI	3
AO		3	DSAO	0

IO Tag	PID Drawing No.	I/O Type	Description	PLC	Comments
LSH-105	I-01	DI	Suction Side Sump High Level	Booster Pump Station PLC	
YA-101A	I-01	DI	Booster Pump No 1 E-Stop	Booster Pump Station PLC	
ZL-101	I-01	DI	Booster Pump No 1 In Remote	Booster Pump Station PLC	
HS-101	I-01	DO	Booster Pump No 1 Start/Stop	Booster Pump Station PLC	
YL-101	I-01	DI	Booster Pump No 1 Run	Booster Pump Station PLC	
YA-101B	I-01	DI	Booster Pump No 1 Fail	Booster Pump Station PLC	
II-101	I-01	AI	Booster Pump No 1 Current	Booster Pump Station PLC	
TAH-101	I-01	DI	Booster Pump No 1 High Bearing Temperature	Booster Pump Station PLC	
PAL-101	I-01	DI	Booster Pump No 1 Low Pressure	Booster Pump Station PLC	
SI-101	I-01	AI	Booster Pump No 1 Speed	Booster Pump Station PLC	
SC-101	I-01	AO	Booster Pump No 1 Speed Setpoint	Booster Pump Station PLC	
PAH-101	I-01	DI	Booster Pump No 1 High Pressure	Booster Pump Station PLC	
YA-102A	I-01	DI	Booster Pump No 2 E-Stop	Booster Pump Station PLC	
ZL-102	I-01	DI	Booster Pump No 2 In Remote	Booster Pump Station PLC	
HS-102	I-01	DO	Booster Pump No 2 Start/Stop	Booster Pump Station PLC	
YL-102	I-01	DI	Booster Pump No 2 Run	Booster Pump Station PLC	
YA-102B	I-01	DI	Booster Pump No 2 Fail	Booster Pump Station PLC	
II-102	I-01	AI	Booster Pump No 2 Current	Booster Pump Station PLC	
TAH-102	I-01	DI	Booster Pump No 2 High Bearing Temperature	Booster Pump Station PLC	
PAL-102	I-01	DI	Booster Pump No 2 Low Pressure	Booster Pump Station PLC	
SI-102	I-01	AI	Booster Pump No 2 Speed	Booster Pump Station PLC	
SC-102	I-01	AO	Booster Pump No 2 Speed Setpoint	Booster Pump Station PLC	
PAH-102	I-01	DI	Booster Pump No 2 High Pressure	Booster Pump Station PLC	
FIT-104	I-01	AI	Discharge Header Flow	Booster Pump Station PLC	
PIT-107	I-01	AI	Booster Pumps Common Suction Header Pressure	Booster Pump Station PLC	
AUT-201	I-01	AI	Booster Pumps Common Suction Header Total Chlorine	Booster Pump Station PLC	
AHA-201	I-01	DI	Booster Pumps Common Suction Header Total Chlorine High Alarm	Booster Pump Station PLC	
PIT-108	I-01	AI	Discharge Header Pressure	Booster Pump Station PLC	
LSH-106	I-01	DI	Discharge Side Sump High Level	Booster Pump Station PLC	
YA-103A	I-02	DI	Booster Pump No 3 E-Stop	Booster Pump Station PLC	
ZL-103	I-02	DI	Booster Pump No 3 In Remote	Booster Pump Station PLC	
HS-103	I-02	DO	Booster Pump No 3 Start/Stop	Booster Pump Station PLC	
YL-103	I-02	DI	Booster Pump No 3 Run	Booster Pump Station PLC	
YA-103	I-02	DI	Booster Pump No 3 Fail	Booster Pump Station PLC	
II-103	I-02	AI	Booster Pump No 3 Current	Booster Pump Station PLC	
TAH-103	I-02	DI	Booster Pump No 3 High Bearing Temperature	Booster Pump Station PLC	
PAL-103	I-02	DI	Booster Pump No 3 Low Pressure	Booster Pump Station PLC	
SI-103	I-02	AI	Booster Pump No 3 Speed	Booster Pump Station PLC	
SC-103	I-02	AO	Booster Pump No 3 Speed Setpoint	Booster Pump Station PLC	
PAH-103	I-02	DI	Booster Pump No 3 High Pressure	Booster Pump Station PLC	
LIT-201	I-03	AI	Air Bladder Level	Booster Pump Station PLC	
YA-202	I-03	DI	Heat Trace Controlle Fault	Booster Pump Station PLC	
YA-305	I-04	DI	HVAC Smoke Alarm	Booster Pump Station PLC	
FAL-305	I-04	DI	HVAC Low Flow	Booster Pump Station PLC	
TAH-305	I-04	DI	HVAC High Temperature	Booster Pump Station PLC	
TAL-305	I-04	DI	HVAC Low Temperature	Booster Pump Station PLC	
YL-305	I-04	DI	HVAC Fail to Run	Booster Pump Station PLC	
UI-301	I-04	DSAI	Generator Indicator	Booster Pump Station PLC	
LAL-301	I-04	DI	Generator Low Fuel	Booster Pump Station PLC	
LAH-301	I-04	DI	Generator Containment High Level	Booster Pump Station PLC	
YA-301	I-04	DI	Generator Fault	Booster Pump Station PLC	
YL-301	I-04	DI	Generator Run Status	Booster Pump Station PLC	
YL-400A	I-04	DSDI	PLC Panel Battery Power	Booster Pump Station PLC	
YA-400A	I-04	DSDI	PLC Panel UPS Fail	Booster Pump Station PLC	
YL-400B	I-04	DSDI	PLC Panel Low Battery	Booster Pump Station PLC	
YA-400B	I-04	DSDI	PLC Panel General Alarm	Booster Pump Station PLC	
TAH-400	I-04	DSDI	PLC Panel High Temperature	Booster Pump Station PLC	
YL-400	I-04	DSDI	PLC Panel Power	Booster Pump Station PLC	
ZLC-303	I-04	DI	Utility Power Circuit Breaker Closed	Booster Pump Station PLC	
ZLO-303	I-04	DI	Utility Power Circuit Breaker Opened	Booster Pump Station PLC	
ZL-303	I-04	DI	Utility Power Circuit Breaker Withdrawn	Booster Pump Station PLC	
YA-303	I-04	DI	Utility Power Circuit Breaker Tripped	Booster Pump Station PLC	
UI-304	I-04	DSAI	Switchgear Indicator	Booster Pump Station PLC	
YS-301C	I-04	DI	ATS Utility Power On	Booster Pump Station PLC	
YS-301A	I-04	DI	ATS Utility Power Fail	Booster Pump Station PLC	
YS-301D	I-04	DI	ATS Emergency Power On	Booster Pump Station PLC	
YS-301B	I-04	DI	ATS Emergency Power Fail	Booster Pump Station PLC	
YS-301E	I-04	DI	ATS Pre-Transfer Signal	Booster Pump Station PLC	
YA-301F	I-04	DI	ATS Phase Loss Alarm	Booster Pump Station PLC	
UI-306	I-04	DSAI	Switchgear Indicator	Booster Pump Station PLC	
ZLC-307	I-04	DI	Emergency Power Circuit Breaker Closed	Booster Pump Station PLC	
ZLO-307	I-04	DI	Emergency Power Circuit Breaker Opened	Booster Pump Station PLC	
ZL-307	I-04	DI	Emergency Power Circuit Breaker Withdrawn	Booster Pump Station PLC	
YA-307	I-04	DI	Emergency Power Circuit Breaker Tripped	Booster Pump Station PLC	

APPENDIX CP-01

Reference Drawings: I-01, I-02, I-03

A. Process Overview

1. Three (3) pumps shall be provided under Division 43 to send potable water from the City of Warren's Water Filtration Plant to the Trumbull Energy Center (TEC). The pump station will boost the pressure and flow of water sent to TEC in order to meet adequate pressure and flow requirements.

B. Control Equipment

1. Each Pump is supplied with a Variable Frequency Drive (VFD) located in the Electrical Room. Each VFD also serves as the local control station for the associated Pump and includes the following operator devices for Pump operation:
 - a. Pump Local/Off/Remote (LOR) selector switch
 - b. Pump VFD Operator Interface (OI)
 - c. Pump Speed Control (via the VFD OI)
 - d. Pump Start and Stop Control (via hardwired pushbuttons on the front of the VFD **or** via the VFD OI)
 - e. Pump Reset (via the hardwired pushbutton)
 - f. Various Pump status indicators (via hardwired pilot lights on the front of the VFD **or** via the VFD OI), including but not limited to:
 - i. Pump Run status
 - ii. VFD Fail Alarm
 - iii. Speed Indication
 - iv. Off Status
2. The Pump Station flow is monitored by the Discharge Header Flow Meter and recorded by the Plant SCADA.
3. The pressure on the discharge of each pump is monitored by the Discharge Pressure Switch and is compared against the expected operating pressure setpoint. If the discharge pressure is higher than expected, a HIGH DISCHARGE PRESSURE warning is initiated.
4. The pressure on the suction side of each pump is monitored by the Suction Pressure Switch and is compared against the expected operating pressure setpoint. If the suction pressure is lower than expected, a LOW SUCTION PRESSURE warning is initiated.
5. The Pump Station pressure is monitored by the Discharge Header Pressure Transmitter and recorded by the Plant SCADA.

6. The hard-wired logic is in the VFD. Motor stator, motor bearing and pump bearing temperature will be interlocked via relay. Should the temperature exceed the high-high limit the pump will shut down, the PLC start/stop output contact will be de-energized, and the motor high temperature alarm signal shall be generated. A high temperature alarm will be generated prior to the temperature reaching the high-high limit shut down. The operator should take action to avoid the high-high shut down condition.

C. Control Operations

Local Manual Control:

A pump may be manually operated at the associated VFD panel. Placing the Local-Off-Remote (LOR) switch in the Local position and pressing the start pushbutton shall start the equipment; pressing the stop pushbutton shall stop the equipment. In addition, speed can be set via VFD OI.

Remote Manual Control:

Note: The Remote Manual Control Mode shall be used for maintenance and troubleshooting purposes only. The Pumps are designed to operate normally in the Remote Automatic Control Mode.

A common control station (OIT/HMI graphic) shall be developed for each pump. The station shall provide the following for each pump: status (Run, Remote, and Motor Overload), runtime, motor high temperature, and manual S/S controls. With the VFD LOR switch in remote position and selecting "Manual" mode from HMI, the associated pump may be manually started or stopped by an authorized operator at the HMI. To adjust the speed of the Pump in the Remote Manual Control Mode, a speed setpoint is entered in the HMI system from a control station. This setpoint is entered as a percentage (50 – 100%).

Remote Automatic Control

Note: The Remote Automatic Control Mode shall be used for normal operating conditions.

Note: All Three pumps must be placed in the Remote Automatic Control Mode for proper lead/lag/standby and automatic operation. If one pump is Off or Out of Service the remaining pump will operate based on the Automatic Control described below, and the lead/lag/standby rotation logic will be bypassed.

1. Placing all Pumps VFD LOR selector switches in Remote Mode disables the pushbuttons located on the VFDs and enables control from the HMI.
2. Placing the Pump VFD LOR selector switches to the Remote position and A/M switch at HMI in Auto position will enable the Remote Automatic Control mode.
3. Pump Automatic Control:
 - i. In Automatic Control mode pumps can start, stop, and vary speed based on the pressure demand setpoint. Pressure demand setpoint can be entered / updated into the system via HMI pressure control station.
 - ii. Once placed in Remote Automatic Control Mode, the Lead pump will start at 50% speed.
 - iii. Operating discharge pressure setpoint (operator adjustable) shall be set to 75PSI initially which is typical for Booster Pump Station operation. A

discharge header pressure of less than 75 PSI increases the Lead pump speed gradually until the discharge pressure reaches setpoint. If Lead pump reaches 100% of speed before pressure setpoint can be reached, Lead pump shall be dropped to 50% speed and Lag pump shall be called to run at 50% speed. Then both Lead and Lag pumps speed shall be increased gradually to reach the discharge pressure setpoint. If the pressure remains less than the setpoint for a set time, a Low-Pressure alarm is generated.

- iv. A discharge header pressure of more than 75 PSI will reduce Lead and Lag pump speeds gradually to maintain the pressure setpoint. and stop the Lag pump if both pumps reach 50% speed and run only Lead pump. If the pressure remains greater than 75 PSI for a set time, a High-Pressure alarm is generated.
- v. At any point when Lead or Lag pump is called to run and it fails to run, Standby pump should be called to run in its place.
- vi. Pump Parameters shall be programmed into the VFD. To enhance pump efficiency, VFD shall adjust the pump speed based on pump parameters and pressure demands. Refer to Specifications Section 26 29 23 Variable Speed Drive Unit for details.
- vii. The Lead/Lag/Standby configuration of the Pumps shall be rotated weekly (operator adjustable) to ensure equal run time between the Pumps.

Note 1: All pressure setpoints and timers shall be adjustable at the HMI at the Supervisory level.

Controller Programmed Safety interlocks:

- 1. The PLC Logic will process all pump start/stop commands under the supported operating modes.
- 2. A Pump E-stop output shall be triggered, run inhibited and HMI equipment alarm generated if any of the conditions listed below are detected by the PLC:
 - a. Thermal overload
 - b. Low suction pressure
 - c. High discharge pressure
 - d. VFD Fail

- END OF SECTION-

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SECTION 40 61 96 – PROCESS CONTROL DESCRIPTIONS

PART 1 -- GENERAL

1.01 DOCUMENT CONVENTIONS AND PURPOSE

- A. The following terms, used throughout this document, shall be as defined below:
 - 1. “Will”, “shall” or “must” indicates a mandatory requirement or course of action.
 - 2. “Should” indicates a recommended requirement or course of action
 - 3. “May” or “can” indicates a possible course of action.
- B. This document outlines the basic control philosophy for the Facility and describes the site process control requirements to be read in conjunction with the various mechanical equipment specification sections and referenced against the project Process and Instrumentation Drawings (P&IDs), electrical control schematics, specs and plans.
- C. Any deviation from the requirements of this document must be approved in writing by the Engineer of record or authorized representative.

1.02 THE REQUIREMENT

- A. General: The Contractor, through the use of a qualified and directly contracted System Integrator, shall be responsible for configuring and programming PLC and HMI hardware for implementation of the control philosophies described in this section, the functions detailed on the Contract drawings, and the points listed in the I/O schedule. The requirements of Specification Section 40 61 00 – Process Control and Enterprise Management Systems General Provisions apply to this section. Vendor package suppliers, also under contract with Contractor, shall be subject to the same responsibilities and requirements (and further as detailed in section 2.1).
- B. PLC controller programs shall be capable of functioning normally in the absence of an HMI station without any special modifications. Process logic, including monitoring, control and alarming functions shall be programmed at the PLC controller level only. Vendor PLC-based control packages shall be subject to the same requirements.

1.03 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

A. Reference Specifications

40 61 00	Process Control and Enterprise Management Systems General Provisions
40 62 02	PLC Based Control System Hardware
40 68 00	PLC Based Control System Software

1.04 ABBREVIATIONS AND ACRONYMS

A. Abbreviations used in this section:

A/M	Auto/Manual
AAH	Analyzer Alarm High
AAHH	Analyzer Alarm High-High
AAL	Analyzer Alarm Low
AALL	Analyzer Alarm Low-Low

ACK	Acknowledge
AOP	Advanced Oxidation Process
ATC	Automatic Transfer Controller
AWT	Advanced Water Treatment
CEB	Chemically Enhanced Backwash
CIP	Clean-In-Place
DCS	Distributed Control System
DLR	Device Level Ring
DOL	Direct On-Line (Starter)
EED	(Target) Electrical Energy Dose
FAL	Flow Alarm Low
FAH	Flow Alarm High
GPS	Global Positioning System
GUI	Graphic User Interface
HMI	Human Machine Interface
HOA	Hand-Off-Auto
HOR	Hand-Off-Remote
I/O	Input / Output
L/R	Local/Remote
LAH	Level Alarm High
LAHH	Level Alarm High-High
LAL	Level Alarm Low
LALL	Level Alarm Low-Low
LCP	Local Control Panel
LCS	Local Control Station
LO	Locked Out
LOA	Local-Off-Auto
LOR	Local-Off-Remote
MF	Membrane Filtration
MBR	Membrane Bioreactor
MCC	Motor Control Center
MLR	Mixed Liquor Return
MPRM	Motor Protection Relay Module
NAS	Network Attached Storage
NPW	Non-Potable Water
NTP	Network Time Protocol
OCA	Open-Close-Auto
OI	Operator Interface
OSC	Open-Stop-Close
PAH	Pressure Alarm High
PAHH	Pressure Alarm High-High
PAL	Pressure Alarm Low
PALL	Pressure Alarm Low-Low
PD	Positive Displacement
PID	Proportional + Integral + Derivative
PLC	Programmable Logic Controller
RAS	Return Activated Sludge
RED	Reduction Equivalent Dose
RIO	Remote Input / Output
RO	Reverse Osmosis
RVSS	Reduced Voltage Soft Starter
SCADA	Supervisory Control and Data Acquisition
SOP	Standard Operating Procedure
S/S	Start/Stop
TAH	Temperature Alarm High

TAHH	Temperature Alarm High-High
TBC	To Be Confirmed (By the Engineer prior to or at the FAT)
TBD	To Be Determined (By the Engineer or Vendor during field commissioning)
UPS	Uninterruptible Power Supply
UV	Ultra-Violet
UW	Utility Water
VCP	Vendor Control Panel (Supplied by Equipment or Package Vendor)
VFD	Variable Frequency Drive
VSD	Variable Speed Drive (Integral to Metering Pumps)
WAS	Waste Activated Sludge

- B. The Contractor (and Vendor package suppliers) shall reference mechanical drawings and specification sections and electrical equipment location plans, specifications and control schematics as noted on the P&ID drawings for additional control clarifications.

PART 2 -- PRODUCTS

2.01 CONTROL SYSTEM ARCHITECTURE

- A. Required PLC controller and communication cabinets (as shown on the Network Block Diagrams) shall be furnished configured, programmed and fully tested by the System Integrator. PLC controller programming shall be as described herein. The PLC controllers shall be used to automatically monitor and control equipment provided under this contract.
- B. Required package vendor PLC panels shall be factory-assembled, configured and programmed by the package vendor as described herein and elsewhere in the contract documents – all as confirmed by the Engineer in the certified vendor submittals. The vendor package PLCs (as specified in Section 40 62 02 – PLC Based Control System Hardware) shall be used to automatically monitor and control equipment provided in the associated vendor package. The vendor package HMI hardware specified in Section 40 62 02 – PLC Based Control System Hardware and shown on the Network Block Diagrams (where applicable) shall be used to facilitate a GUI for package system monitoring, operator setpoint entry, and operator interface to the package PLC control functions.
1. Note: For networked vendor packages, the Vendor shall be subject to specific programming requirements to ensure that a parallel HMI interface to the Vendor PLC - Plant master HMI and the Vendor OI - can be properly managed without input handling conflict at the Vendor PLC.
- C. The Contractor shall be responsible for field assembly, installation, pre-commissioning, final commissioning and startup of the control network components as detailed in specification Section 40 61 00 – Process Control and Enterprise Management Systems General Provisions.
- D. System Overview:
1. The control system architecture, as shown on the network overview drawings, will be largely based on the Schneider Electric Modicon line of PLC processors.
 2. One desktop control system interface workstation, furnished with the necessary SCADA client software and support applications, will be provided for the operations staff. The control system screens provided will allow for monitoring and control of the various process systems including support for replicated Vendor package

control screens, alarm monitoring, historical data trending and report generation/viewing.

3. Major vendor control packages with single controllers will be entirely based on the Schneider Electric line of Modicon controllers with dedicated OI (as developed by the package Vendor). The major vendor control panels will be field located on or in close proximity to the associated equipment skid, directly connected to the plant control network via industrial Ethernet switch and supported by the facility redundant UPS system.
4. Where shown, Schneider Electric chassis-style RIO modules will be used to facilitate marshalling of field I/O. For all VCPs, communication between the RIO module chassis and the associated controller will be via dedicated Ethernet link.
5. All controller cabinets are intended to be normally (common) key-lock secured. By default, the status points listed below will be monitored for all panels and access to the controller IP webpage (as applicable) provided.
 - a. Intrusion Detection
 - b. Failure of Primary Power Supply
 - c. Failure of Secondary Power Supply
 - d. Primary Controller Failure (inclusive of power supply)
 - e. Secondary Controller Failure (inclusive of power supply) – where applicable
6. All equipment drives and starters will be housed within the site Electrical Room. Normal operation of plant equipment will require an active plant PLC. However, Control Room equipment local controls will be provided to support maintenance activities or, in some cases (as identified in the detailed control philosophy sections) override emergency operation. Specifically, starters will include local controls at the starter; access to drive local control functions will be available but password protected; drive / starter local safety interlocks will be provided (as shown on the P&IDs and electrical control schematics) to support direct interface of hardwired mechanical protection signals.
7. To the fullest extent practical, variable speed drives will be interfaced to the Plant PLC and Vendor PLC controllers using a UTP Cat5e Ethernet cabling (for control and monitoring). For each system the drives will be segregated onto separate Ethernet networks for odd-numbered and even-numbered drives to mitigate single point of failure in the design. Status monitoring of UPS units, smart power monitors, motor protection relay modules and select process analyzers will be based on Modbus/RTU protocol (using industrial stranded copper RS-485 cabling). Traditional hardwired copper connections will be used for monitoring of discrete field signals and control of on/off valves, starters and other equipment requiring a discrete control interface. Similarly, traditional shielded conductor pairs will be used for monitoring of analogue field signals and control of modulating valves and other equipment requiring an analogue control / remote setpoint interface. For each field network protocol, configured data transmission rates will be as specified in Section 40 62 02 – PLC Based Control system Hardware. Analog signals of 4-20mA will be proportionally scaled to the measured or control value. Discrete signals will be 24VDC unless specifically noted otherwise. Instruments certified to be HART compatible shall be preferentially supplied.

2.02 PLANT PROCESS OVERVIEW

- A. Variable Frequency Drives (VFDs) will be used for pump motor control at the booster pump station. VFDs enhance operating autonomy, allow flow demand differentials to be met with ease, and are highly energy efficient. Pump isolation valves for each pump will include a suction shut-off valve (butterfly valve) and a discharge shut-off valve (butterfly valve). Each pump will also be equipped with a check valve on the discharge side to protect from backflow when pumps are turned off or a system failure occurs. The control of the station will be based on the flow demand of CEFT. The pumps have been designed to meet a pressure range of 65-85 psi at CEFT for the anticipated range of flow conditions, based on the system hydraulics. The pump station will have remote control capabilities and will primarily be operated from the WTP. The pump station will also have local control capabilities to be operated from the control room inside of the building.

2.03 PLC/HMI CONTROL FUNCTIONS

- A. General: PLC/HMI requirements are as listed in the sub-sections below and are generally applicable to Vendor developed PLC/OI control packages except where specifically noted as "Not Applicable to Vendor Packages".
- B. Development Overview and Access: The PLC HMI shall display the status or value of all PLC controller input and output points described in this section, detailed in the I/O schedule and shown on the P&ID drawings. In addition, the PLC HMI shall serve as a parallel interface point for all networked vendor package controllers, displaying the status or value of all shared I/O points as well as providing access to vendor package control points and setpoint entries. Unless specifically directed otherwise by the Engineer in writing, controller and OI / HMI control screen development requirements shall be subject to the requirements detailed herein. and the following specification sections:
 - 1. Section 40 62 02 – PLC Based Control system Hardware
 - 2. Section 40 68 00 – PLC Based Control Systems Software
- C. Access to the PLC HMI (and vendor control package OIs) will be password restricted to authorized personnel only with increasing authority required to effect system changes. Access rights shall be established at the Domain level. In general, PLC HMI base access groups will be defined as follows:
 - 1. Maintenance Group – view access to specific equipment usage / performance summary screens (with pre-defined historical and real-time trend pop-ups), alarm screens and Viewpoint Navigation screen. No other view, write or control access rights. Alarm acknowledgement will also be restricted.
 - 2. Operations Group – typically granted equipment and process control rights but limited access to process control configuration / tuning parameters. Specific operator adjustable values shall be as defined in the detailed control descriptions. Access to generated (but read-only versions) of system reports and predefined trends shall be supported as well as creation of temporary ad-hoc trends and print screen access.
 - 3. Supervisory Group – typically granted administrative level rights within the control system software environment but only limited (if any) access to the operating system. Supervisors shall have access to all operator adjustable values as well as process control configuration / tuning parameters and alarm configuration. Specific

supervisor tunable values shall be as defined in the detailed control descriptions. Ability to create new trends, modify existing trends, create reports and modify existing report templates shall be supported.

4. Administrator / Developer – full application and operating system level administrative access rights.

D. Controller Setpoint Handling:

1. Operator entered setpoints shall be constrained to match PLC programmed setpoint ranges. If a value lower than the setpoint range is entered, the PLC program defaults to the lowest possible range value. If a value higher than the setpoint range is entered, the PLC program defaults to the highest possible range value. The PLC shall prohibit entry of setpoint values beyond the operational range of a system or process. In general, confirmed PLC setpoint entries become the default program values. All system setpoints are to be made adjustable at the HMI by authorized users as detailed in the individual control philosophy sections.
2. Should a PLC reboot occur, through purpose or uncontrolled event, the PLC program shall be automatically restored with last setpoint entries. No operator intervention shall be necessary to bring a freshly rebooted controller online and operational.

E. Controller Run Output handling: In general, a PLC issued motor run command signal shall be propagated as a maintained contact. However, the PLC run command output signal must be disabled under the following conditions:

1. Equipment stop issued (by the PLC, operator or Local Auto logic).
2. Equipment fail detected.
3. Equipment placed in local control at the equipment, outside of PLC control.
4. Power-loss (black-out) condition detected.
5. If separate START and STOP (or Open and Close) outputs have been allowed for, once initiated, the PLC shall maintain the selected output for no less than 3 seconds to allow the local logic sufficient time to latch in the PLC issued command signal.

F. Significant Digit Usage: All HMI display values will be configured to show a minimum of 1 significant digit except in the following cases where 2 significant digits are required:

1. Flow readings (where the primary reading is scaled to 3 digits or less)
2. Analytical readings

G. Control Mode Definitions – as a function of defining system control logic, it is necessary to define the manner and extent of control available at the major control access layers. Typical access layer control definitions are provided here as reference.

1. Local Control Mode (Field Selected): This mode of control refers to the first line of operator-initiated control functions available at the equipment and/or drive/starter and by definition PLC independent. This mode of operation, although available in

most cases, will be generally restricted to maintenance activities except where specifically noted otherwise.

2. Local Safety Interlocks: This level of control is not selectable and is always active. It specifically refers to protection logic integral to the equipment or equipment package that is directly interlocked with the equipment controls, and which automatically executes regardless of the current method of operation.
 3. Controller Programmed Safety Interlocks: This level of control is not selectable and is always active unless parameter bypass selection is required to be HMI accessible and then invoked by a Supervisor. It specifically refers to protection logic programmed at the PLC with an output that is directly hardwire interlocked with the equipment controls and which automatically executes regardless of the current method of operation. Note: The output will be wired fail-safe such that in the event of controller failure, the equipment will be forced to stop.
 4. Local Auto Control Mode (HMI or Field Selected – subject to package configuration): This mode of control refers to independent operational logic integral to the equipment or equipment package that is responsible for the proper operation of the equipment. The operational logic may execute based on remote command triggers (e.g., start/stop, open/close, etc.) or field inputs (e.g., flow, pressure, level, temperature, etc.). Local auto mode may be bypassed through selection of local control mode (if available).
 5. Remote Manual Control Mode (HMI Selected): This mode of control refers to operator-initiated control functions available via the control system operator interface, HMI or LCP but executed via the PLC control logic (i.e., all PLC process interlocks and safety functions remain engaged).
 6. Remote Auto Control Mode (HMI Selected): This mode of control refers to PLC initiated control functions which are automatically executed and managed by the PLC logic, operator independent.
 7. Other control modes applicable to a specific process or system shall be as defined in Part 3.
- H. Historical Data Collection and Display: The control system shall historically collect, trend and record, in the historical database, all analog input and output data represented on the Contract Drawings and I/O Schedule. In addition, the HMI shall:
1. Log (daily and lifetime) runtimes to the historical database for all monitored equipment.
 2. Log the number of starts to the historical database for all monitored equipment.
 3. Calculate and log daily (and other Part 3 required) flow totals for all measured flows.
 - a. Note: daily flow totals will be summed and recorded over a 24-hr period from 12am to 12am with allowance for daylight savings time (DST) annual time shift.
- I. Trending Format – General: As a minimum, trends shall display the process variable, the transmitter tag, a clear description and the units for both axes. For variables which are controlled by the PLC, both the setpoint and the controlled process variable shall be displayed on the same trend. Where multiple variables are displayed, separate and distinct colors shall be used for each variable along with a color key with clear

descriptions defining each variable. The System Integrator shall be responsible for providing PLC programming to support the above log points. All logic required to develop the above I/O for historical collection at the HMI shall be provided by the System Integrator.

J. Alarm Terminology: The following alarm terms will be used throughout this document.

1. Permissive: PLC tracked Input, status, interlock and/or process variable value required to allow start of a piece of equipment or a process to proceed. Although lack of permissive will inhibit start, loss of permissive will not necessarily generate a fault once the equipment or process is operational.
2. Warning or System Alert (displayed as per project graphics standards): PLC generated low priority alarm intended to alert Operators to process or equipment operation drift outside of norm. Typically, the gap between “warning” and “alarm” is sufficient to allow Operator response to avoid an alarm/trip condition.
 - a. Note 1: System alerts are also utilized at specific field equipment locations to alert area personnel to imminent start of rotating equipment. System alerts (typically in the form of beacons and/or horns) are only used in areas of potentially unsecured (i.e., exposed and/or approachable) rotating equipment which may start unexpectedly.
3. Alarm or Trip (displayed as per project graphics standards) PLC generated high priority alarm or interlock intended to alert Operations to PLC execution of equipment or process protective measures OR imminent fault condition requiring operator intervention / action.

K. Alarm History: The entire system alarm history (inclusive of system warnings, alarms, and advisories) shall be made accessible at the HMI to all authorized users. The Alarm History shall be established as read-only from the moment of system field initialization. An alarm configuration screen at the HMI shall allow a Supervisor to enable or disable any HMI warning or alarm notification without the need to access the control system software back-office tools. Other related requirements:

1. Warnings / Alarms related to HMI displayed field equipment and facilities shall be displayed on the related system control screen as well as recorded in the historical alarm summary. Reference Specification Section 40 68 00 for additional control screen development requirements.
2. Warnings / Alarms may be assigned to one of four (maximum) sub-groups. The alarm sub-groups shall be as defined at the conclusion of the project Graphics Meetings.

L. Fault Detection / Handling:

1. Unresponsive Equipment: In addition to monitoring fail contacts for controlled equipment, if at any point a device fails to start, stop, open or close as commanded by the PLC, a “Fail to Respond” condition shall be generated by the PLC and displayed at the HMI. PLC generated “Fail to Respond” fault, as well as any other logically generated fail condition identified in the detailed control philosophy sections, shall be resettable at the HMI unless specifically noted otherwise. The HMI reset function shall be in the form of a screen button made visible to the Operator at the interlock or control faceplate when a PLC generated fault condition is detected for the associated equipment. “Fail to Respond” specifics shall be as follows:

- a. When a drive or starter is being called to run, default “Fail to Respond” fault delay shall be 10sec. If a drive or starter is called to start and run status is not received before expiration of the fault timer (Supervisor adjustable), the controller shall generate a “Fail-to-Respond” alarm and lock-out the equipment.
 - 1) In general, the “Fail to Respond” time delay timers (for stop commands in particular) will take into account the drive configured spin-down timer.
 - b. When a drive or starter is in operation, if the run status is lost for longer than 3secs (Supervisor adjustable), the controller shall generate a “Fail-to-Respond” alarm and lock-out the equipment.
 - c. In both cases, only an HMI reset will be required to allow the equipment to be restarted.
2. Analog Inputs: The PLC shall generate an instrument or signal fault (Out of Range or PV_Bad) alarm if the analog input from a given field instrument or device is detected to be equal to or less than 3.8mA or equal to or greater than 20.5mA for longer than 10 seconds. The alarm time delay assigned to each signal shall be a Supervisor adjustable value.
 - a. Note: When an instrument is detected to be in fault, system control response to the signal and all associated alarms (e.g., LAHH, LALL, etc.) shall be suspended. Other system response specifics shall be as defined in the Part 3 control detailed control descriptions.
 3. Discrete Instrument Warning / Alarm Contacts: The PLC shall process a discrete warning / alarm contact if the contact is detected to be active for longer than a preset (supervisor adjustable) time delay. The default settings shall be 2 seconds unless specifically noted otherwise in the Part 3 detailed control descriptions.
 - a. Note: discrete signals arriving via drive, starter, actuator, LCP or other device which have already confirmed authenticity of the alarm shall be immediately processed by the PLC without time delay unless specifically noted otherwise in the Part 3 detailed control descriptions
- M. Event Logging: An event log, separate from the alarm history, shall be made accessible at the HMI (read-only from the moment of system field initialization) to all authorized users. The event log shall date/time stamp and record any discrete change in status of the equipment monitored by the PLC (e.g., Auto/Manual, Local/Remote, Run/Off, Open/Close, Forward-Off-Reverse, Intrusion, Start Sequence Change, Alarm Enable/Disable, etc.). Important notes:
1. HMI adjustable setpoint values shall be historically collected and trended against the associated process variable or performance parameter.
 2. Events may be assigned to one of four (maximum) sub-groups. The event sub-groups shall be as defined at the conclusion of the project Graphics Meetings.
- N. Loop tuning parameters: The PLC HMI interface shall be configured to allow supervisory level users to access all loop tuning parameters from the HMI for any control loop. Changing loop tuning parameters shall not require reconfiguring, reprogramming, or reloading of the PLC program. All changes to any loop tuning parameters shall be logged to the historical database and trended as described under paragraph 2.3.L – Event Logging.

- O. Equipment READY Logic: The term “READY” (used throughout this document) shall be interpreted as “being available for PLC control”. The following conditions, as applicable, must be satisfied to achieve “READY” status:
1. Field equipment is Available (powered) AND is currently in Remote and/or Auto mode at the starter/drive/actuator (as applicable) i.e., not in Local Control Mode.
 2. No fail (interlock) conditions pending (including field E-Stop).
 3. No run inhibit (permissive) conditions exist.
 - a. Equipment start via the PLC cannot be achieved without the associated equipment satisfying the above “READY” definition. With initiation via the PLC and run status confirmation, the equipment shall be noted to be in REM AUTO RUN or REM MAN RUN mode depending upon HMI operating mode selection.
 - 1) Note: if the equipment has been started at the starter/drive control interface, the equipment shall be noted to be in LOCAL RUN mode with PLC confirmation of run status
 4. Unless specifically stated otherwise in the detailed control descriptions, it will not be necessary to display a “Not Ready” status if the above conditions are not satisfied. However, fail conditions, run inhibit conditions, local control status and run status should be clearly displayed.
- P. Local Control Station (LCS) Handling Reference: Where shown on the contract drawings, a local control station shall be provided at the field equipment. Each station shall include one push-pull E-Stop button fail-safe hardwired directly to the starter or drive, and which may be engaged with effect regardless of the current operating mode of the equipment or communication means (hardware or fieldbus). Once pressed, the equipment will be immediately disabled at the starter / drive local control level and an alarm generated at the HMI. Release of the LCS E-stop button and reset of the alarm condition at the drive and the HMI will cancel the emergency stop.
- Q. Process Control Deviation: Throughout the various plant processes, the PLC will be required to control and manipulate equipment designed to maintain a preset flow, level, temperature, pressure or other water quality parameter. In general, should the control system fail to maintain the identified process parameter within the operator or system specified deadband for longer than a preset time period (Supervisor adjustable default shall be as nominated within the specific control section and/or the project alarm table), a process warning shall be generated by the PLC and displayed at the HMI. In specific instances (as defined in the Part 3 detailed control descriptions), should the condition persist beyond a second preset time delay, a critical process alarm shall be generated. Additional system response shall be as defined in the specific control section.
- R. VFD Control Coordination: In general, VFD operating parameters critical to proper drive operation will be established at the drive. The PLC control program will be developed to support this arrangement.
1. Where a start delay timer has been set at the pump VFD, the PLC shall be programmed to account for pump start delay in the re-start logic (and fail-to-respond logic) following issue of pump stop command or unexpected pump stop. Where possible the start delay timer shall be displayed at the HMI.
 2. It should be anticipated that the VFD of any given pump may include a custom configuration that does not necessarily support operation over the entire speed

range. The PLC speed control signal (as generated by logic controller or operator entered setpoint) shall be ranged 0 to 100% of maximum and output proportionally from 4-20 mA. The VFD will manage the received signal over its actual configured operating range.

3. For all VFDs, the ramp rate (starting and stopping) shall be as set at the VFD. The PLC PID controller (as applicable) will be tuned to take into account the final VFD ramp rate.
- S. Auto Rotation Logic: Where referenced in the detailed controls section, the start sequence for a system of pumps or other equipment may be automatically established by the PLC or manually established by an authorized Operator.
1. PLC Auto Sequencing: In auto sequencing mode, the equipment start sequence will be automatically rotated by the PLC based on runtime values. Pump runtimes will be continuously compared. Should two or more runtime meters register runtime hours within a +/- 1hr deadband (Supervisor adjustable), the runtimes will be considered equal, and the auto start sequence will default to the numerical order of the equipment in question (i.e., Pump No.1 will be selected to precede Pump No.2 under this runtime comparison scenario). When pump runtimes exceed the deadband limit, the start sequence will be automatically updated. However, pump operation will not normally be impacted by a start sequence change (in Auto or Manual sequencing mode): pump start/stop re-order will be applied as a normal function of pump Cascade start/stop operation unless specifically noted otherwise in the Part 3 detailed control descriptions. Auto PLC rotation may also be suspended by an authorized Operator via the HMI and the pump start sequence manually selected by the operator by means of an HMI pump start selection matrix.
 - a. Override Auto Sequencing Runtime Comparator: An override sequencing runtime comparator will be provided and made adjustable by authorized Operator (default = 72hrs). Under auto sequencing mode, should the pump(s) remain in continuous operation for a period greater than the preset runtime comparator, the controller logic will auto cycle the pumps to match the current pending start sequence. For forced rotation, the new pump will always be started and confirmed running prior to shutdown of the current in-operation pump (unless specifically noted otherwise in the Part 3 detailed control descriptions).
 2. Operator Manual Sequencing: An authorized operator may manually establish the start sequence for a system of equipment by means of a matrix selection chart at the associated system HMI control screen. For manual start sequence entry, the operator will be required to enter a start position next to each equipment number. The selection interface will be programmed with a means of directing the PLC to accept or cancel the entered start sequence. Once the Operator has completed the start sequence, the PLC must be directed to accept the sequence in order for the entries to be written to the appropriate active PLC registers. Directing the PLC to cancel will clear all proposed entries. Submitted start sequences containing duplicate and/or invalid entries will be automatically rejected and not written to the active PLC registers (thereby retaining the original start sequence). Until the start sequence modifications are accepted, the PLC will ignore all unaccepted start sequence modifications and continue to operate equipment based on the current start sequence.
- T. Bumpless Remote Auto to Remote Manual Transition: Changing the HMI control status of PLC controlled equipment from Remote Auto to Remote Manual shall be a bumpless operation. Therefore, a VFD operating in Auto mode at 78% of maximum

speed shall maintain that speed and remain in operation when switched from Auto to Manual control at the HMI. A similar adjustment to a modulating valve actuator should display identical behavior.

- U. Flow Signal Dampening: Various flow meters are used to measure the rate of flow of water, air and chemicals throughout the facility. The PLC shall be programmed to dampen the incoming analog signal. This shall be accomplished by calculating a running average of the flow signal over 5-second periods (nominal setpoint) using a data sample rate of 0.5 seconds. The means for a supervisor to enable/disable this function and adjust the sampling period (fixed options of 5-sec, 10-sec and 15-sec) at the HMI shall be provided. Refer to individual process control sections (listed in the Appendices) for specific application.
- V. Out of Service: The control system shall have the capability to assign an “Out-of-Service” tag to equipment monitored by the control system. During extended periods of maintenance and/or repair, an operator may make such an assignment so as to suppress associated alarms and inhibit HMI/DCS control functions.
 - 1. Note: normal “lockout / tag-out / check-out” procedures will need to be followed with the field equipment and associated electrical feeds.
- W. Control System Historian: The System Integrator shall register the redundant SCADA Servers (as identified on the Control Network Architecture Drawings) with the site Historian and configure the server to historically collect the analog, event and alarm data collected at the active SCADA Server. With loss of communication to the active SCADA server, the Historian shall automatically engage the redundant server pending auto fail-over active status promotion. In the event of communication loss with both SCADA Servers, the Historian shall automatically backfill the historical database, in chronological order, once communications are re-established with an active SCADA Server.
 - 1. Once the Historian server is installed and configured, the System Integrator shall be responsible for verification of communication connection stability/reliability, confirmation of required data backfill and collection and complete test of the data collection redundancy scheme with the Engineer and Owner representatives as witness. Customized reports and trends shall be developed by the System Integrator as detailed in Specification Section 40 68 00.
- X. Control Philosophy Refinement: It shall be understood that some refinement and/or minor modification of the control philosophy will be necessary over the course of the project as part of the control system configuration and programming work. Forums for informal discussions and clarifications have been provided in these documents. They include the Pre-submittal Conference, Graphics/Reports Development Workshops, Factory Testing, Field Development Phase and Startup. Note: All timer, level, position, analysis, pressure, temperature and flow rate values noted within the control philosophy sections are provided for reference only and are subject to refinement based on system testing and final construction.
 - 1. Where the control philosophy sections reference control screens to be developed, final control screen development will be subject to the requirements of Specification Section 40 68 00 – PLC Based Control system Software and the production agreements reached during the project Graphics/Reports Development workshops.

PART 3 -- EXECUTION

3.01 DETAILED CONTROL PHILOSOPHY SECTIONS

- A. The listed detailed control philosophy sections shall be developed in accordance with Parts 1 and 2 of this specification. The sections are provided as appendices to this specification with the indicated CP-XX reference.

Control Philosophy (CP)	Description
Appendix CP-01	Booster Pump Station

END OF SECTION

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SECTION 40 62 02 – PLC BASED CONTROL SYSTEM HARDWARE

PART 1 -- GENERAL

1.1 THE SUMMARY

- A. The CONTRACTOR through the use of the System Supplier shall provide the programmable logic controllers (PLC)-based control system (PBCS) hardware for the PCIS, complete and operable, in accordance with the Contract Documents. The PBCS shall be furnished complete with all system software as indicated in Section 40 68 00 – PLC-Based Control Systems Software.
- B. The System Supplier shall be responsible for selecting, sizing, and providing the correct and necessary type and quantity of hardware for the entire PBCS and for each PLC. The necessary hardware and software shall include but not limited to servers, workstations, network hardware, PLC input/output (I/O) modules, interconnecting cables, accessories, communication ports, adapters and cards, and all appurtenances for proper operation of the PBCS and to meet the functional requirements described in these specifications, and as shown on the system architecture diagram or network diagram. The System Supplier shall be responsible for the interface to existing systems or those furnished by others. The System Supplier shall also provide the latest version of software to enable the programming and the integration of the PBCS.

1.2 REFERENCE SPECIFICATIONS, CODES AND STANDARDS

- A. Section 40 61 00 - Process Control and Enterprise Management Systems
- B. Section 40 68 00 – PLC-Based Control System Software
- C. Applicable Sections in Division 40 – Instrumentation and Control for Process Systems
- D. Division 26 – Electrical
- E. Division 27 - Communication
- F. The PBCS equipment, materials, and other work shall conform to the specifications; codes and standards requirements specified Section 40 61 00 - Process Control and Enterprise Management Systems.

1.3 ACTION SUBMITTALS / INFORMATIONAL SUBMITTALS

- A. The PLC submittal shall be provided in accordance with the requirements specified in Section 40 61 00 – Process Control and Enterprise Management Systems.

1.4 CLOSEOUT SUBMITTALS

- A. Software: The CONTRACTOR shall provide and register the OWNER with all user software and hardware licenses. Additional contract, agreements and licenses requirements shall be in accordance with Section 40 61 00 - Process Control and Enterprise Management Systems.

1.5 MAINTENANCE MATERIAL SUBMITTALS

- A. Spare Parts: It is intended that sufficient spare parts and supplies necessary to support the operation and maintain the system shall be furnished with the system. These spare

parts are in addition to the “spare” I/Os listed in the I/O list. PLC system spare parts shall be furnished in accordance with Section 40 61 00 - Process Control and Enterprise Management Systems. As a minimum, the spare parts listed below be included in the suggested optional spare parts list that will be provided a specified in Section 40 61 00 - Process Control and Enterprise Management Systems.

- a. One (1) PLC I/O card of each type.
- b. One (1) PLC CPU
- c. One (1) PLC memory card
- d. One (1) PLC communication module (if a separate module is required)
- e. One (1) PLC power supply
- f. OIT memory card

1.6 WARRANTY

- A. The CONTRACTOR shall guarantee the performance of all the new PLCs and the programming software for them as specified elsewhere in the Contract Documents.
- B. All parts, material labor, travel, subsistence, or other expenses incurred in providing services and service visits during the warranty period shall be borne by the CONTRACTOR under the guarantee. Equipment, software, and materials that do not achieve their intended purpose shall be replaced by the CONTRACTOR to attain compliance, at no additional cost to the OWNER.
- C. Guarantee and special corrections of defects and software upgrade requirements and warrantee shall be in accordance with Section 40 61 00 - Process Control and Enterprise Management Systems.

PART 2 -- PRODUCTS

2.1 PROGRAMMABLE LOGIC CONTROLLER (PLC)

- A. Description:
 - 1. The PLC shall be Modicon Unity Momentum part number 171CBU98090.
 - 2. The CONTRACTOR shall furnish all necessary hardware, software, interconnecting cables, all accessories, and all appurtenances as indicated herein or as required for proper operation of the PLC.
 - 3. All PLC materials and equipment furnished for the PLC shall be standard off-the-shelf commercially available products and shall be the product of a single manufacturer.
 - 4. All components that are common to the PLCs shall be of the same manufacturer and family of PLCs. All the PLCs shall have the same components manufacturer (e.g. processor, memory, chassis style, I/O cards, etc.). Special minor interface

hardware not provided by the PLC manufacturer can be a product by the manufacture's approved third party.

5. The CONTRACTOR shall size each PLC in accordance with the I/O list.

B. Performance / Design Criteria:

1. The PLCs shall be designed and constructed for satisfactory operation and long, low maintenance service under the following environmental conditions:
 - a. Ambient temperature range: 0°C through 60°C
 - b. Thermal shock: 1.0° (1.8°F) per minute maximum
 - c. Relative humidity: 95 percent maximum non-condensing
2. Construction: The PLC central processing unit (CPU) shall be modular unit which shall contain the operating logic. The input/output (I/O) modules shall also be modular and interface directly with the CPU through a back common panel or by a special cable if I/O expansion is required. The PLC shall provide a means for mounting the chassis in a standard cabinet or 19-inch rack. The PLC shall be capable of operating in a hostile industrial environment (i.e., heat, electrical transients, RFI, vibration, etc.) without fans, air conditioning, or electrical filtering and be designed to provide high reliability specifically in this process application.
3. The PLC shall be of modular, field expandable design allowing the system to be tailored to this process control application. The capability shall exist to allow for expansion of the system by the addition of hardware and/or user software. The PLC shall be provided with I/O (input/output) modules and with sufficient memory, power and appropriate cables to be able to interface with new and existing field devices, necessary to function as a complete and operable PLC system.
4. Logic functions must perform in a given application shall be programmed into the PLC memory. All equipment shall be capable of tolerating and capable of riding through a power interruption of 8 milliseconds or less without interruption of normal operation and communication.
5. It is the intent of these specifications to provide PLCs which can be easily expanded and configured. Therefore, all changes in system architecture, expansion of I/Os, modification to and implementation of control strategies shall be easily done on-site
6. The PLC shall be capable of communicating with remote I/O racks or other PLCs via fiber optic cable up to 10,000 cable feet or copper cable up to 300 cable feet from the processor without requiring additional communications hardware except for fiber-to-copper modules.
7. PLC Growth Provisions
 - a. All equipment and resources, including PLC, I/O cards and implementation services, shall be provided such that project memory and I/O growth can be implemented into the PBCS without any additional cost to the OWNER.
 - b. CPU memory reserve capacity for project growth shall also 20 percent.
 - c. The I/O points included in the 20 percent project I/O growth requirement shall be termed "implemented spare I/O" (wired to field terminals). The 20 percent

implemented spare I/O is 20 percent of each type of the total project I/O listed and may be implemented in any one or more I/O cards and racks at the direction of the OWNER at any time throughout the duration of the project until the beginning of factory testing. Subsequent to factory testing the unused implemented I/O, if any, shall be delivered to the OWNER as spare I/O.

- d. Implementable spare I/Os shall mean that each of these I/O shall also be wired to the field interface terminals.
- e. Future and Spare Signal (i.e. the source of inputs or final control elements for DO and AO are not yet known or available in the field). The percent of additional terminals for future signals (not implemented) shall be in accordance with the requirements specified in Section 40 67 00 - Control Systems Equipment Panels and Racks.
- f. Spare Empty I/O Module Slots: Each new PLC location shall be provided with three (3) empty I/O module slots.

8. Central Processor Unit

- a. The central processor shall contain all the software, relays, timers, counters, registers, sequencers, and arithmetic capability necessary to perform the specified control functions. It shall be sized to be capable of interfacing with sufficient discrete inputs and outputs, analog inputs and outputs to meet the specified requirements plus the required project percent growth as specified above, or as required by the I/O list, whichever is greater. The CPU shall be a self-contained unit, and shall provide control program execution and support remote or local programming. The PLCs shall be provided to support and implement closed loop floating and PID control which is directly integrated into the PLC program.
- b. The CPU shall be furnished with a watchdog timer. The processor shall have a key type memory protect switch to prevent unauthorized program changes.
- c. The CPU shall perform internal diagnostic checking within the system and give visual indication to the user when no fault is detected and when a fault is detected. If power to the CPU fails or gets disconnected the processor shall cease operation, forcing all outputs off.
- d. The CPU shall have the capability of addressing up to 3072 input and 3072 output points and to communicate with up to 64 physical locations.

9. Memory

- a. The PLC shall be supplied with sufficient memory to implement the specified control function plus a reserve capacity for project growth requirements as specified above. This reserve capacity shall be totally free from any system use.
- b. A minimum of 32 Mbytes of RAM shall be furnished with each PLC. This memory is the total user memory of programming and data, and includes the spare capacity. This reserve capacity shall be totally free from any system use. RAM memory shall hold the specific configuration, measuring and control functions and constraints, set points, and real-time I/O data. Additional memory shall be furnished where necessary to accommodate the I/Os and functional requirements.

- c. The memory shall be programmed in a multi-node configuration with multiple series or parallel contacts, counters, timers, and arithmetic functions.
- d. It shall be possible to upgrade to a processor with a larger memory size simply by saving a program, replacing the processor, and downloading the program to the new system without having to make any program changes.
- e. User memory in the processor not used for program storage shall be separated from main memory for the purpose of data storage.
- f. Battery: The PLC memory shall have a battery backup or other means of backup. The programming memory shall be with sufficient backup to retain the program during power interruptions of up to 1 year. The capability shall exist to remove all batteries from the system without removing system power. An indicator shall show the status of the batteries (if used). A low battery condition must be detectable in ladder logic, but shall not automatically generate a major fault.

C. Materials / Components

1. Communication Ports and Network Interface

- a. General: The PLC shall be able to communicate to the SCADA central computer system and/or other PLCs over a network and allow industry standard repeaters, bridges, routers, and gateways on the network in order to access other PLCs and host computers.
- b. Each PLC shall be furnished with the following multiple on-board Ethernet communication ports. Each Ethernet port shall have industry standard fast Ethernet TCP/IP communication capabilities to communicate over twisted pair cabling or fiber optic cable as applicable. Depending on the PLC manufacturer, additional module as required, depending on the PLC manufacturer. (Third party adapters are acceptable):
 - 1) 100BASE-TX (IEEE 802.3u) – twisted pair
 - 2) 100BASE-FX – Fiber optic cable
 - 3) 1000BASE-T (802.3ab) – Twisted pair
 - 4) 1000BASE-X (802.3z) – Fiber optic cable
- c. A dedicated port for PLC programming shall be provided without the need to disconnect communication operation from one of the other ports. A USB port or serial port that supports RS-232-C, RS-422, and RS-423A signals shall be provided for that purpose, or for access to peripheral devices such as bar code scanners, etc.

2. Input / Output Modules

- a. General
 - 1) All I/O housings and I/O modules shall suitable for hostile industrial environments as described above. All I/O modules shall be isolated and conform to IEEE Surge Withstand Standards and NEMA Noise Immunity Standards. Modules shall be removable without having to disconnect

wiring from the module's terminals by means of a swing-arm or plug-in wiring connector. Sufficient input and output modules shall be provided with at each PLC location to implement the specified control functions plus the required project percent growth and spare of I/O as specified above or as required by the I/O list, whichever is greater. The I/O modules shall be from the same manufacturer as the processor.

b. Power input (see also paragraph "PLC Power Supply"):

- 1) The modules shall operate on an external 120 VAC power supply. The 120 VAC power shall be applied ("wet") to the DI loops and a 24 VDC shall be applied for 2-wire analog input loops.

- c. During normal operation, a malfunction in any remote input/output channel shall affect the operation of only that channel and not the operation of the CPU or any other channel. Any remote input/output channel shall be field selectable to shut down the CPU upon failure of that channel. Upon remote channel shutdown the CPU shall see all inputs on the malfunctioning channel as they were when the shutdown occurred and all outputs shall de-energize on that channel.
- d. All internal logic and circuits shall be isolated from and external power circuits. This isolation shall meet the minimum IEEE specification of 1500 VRMS.
- e. Combination Modules – A Module that provides a combination of discrete inputs and outputs or analog inputs and outputs can be used as long as the I/O quantities meet the system requirements. The specification of each group if I/O must also meet the specification as if it is an individual type module.

3. Discrete Input Modules

- a. Discrete (digital) input (DI) module shall accept DI signals, which is defined as a dry relay contact closure inputs signal from devices external to the PLC. The module shall accept a maximum of 32 inputs. PLC module Input modules shall be shielded from short time constant noise and 60-Hz pickup. Individual inputs shall be optically isolated for low energy common mode transients to 1500 volts peak from user's wiring or other I/O modules and shall have IEEE surge withstand protection. All inputs shall be isolated from each other. The modules shall have LED lights to indicate a discrete input. Input signal level shall be 24 VDC.
- b. The module shall be capable of accepting normally open and normally close input contacts, and to change the input in the module through programming if the contact in the field changes from normally open contact to normally close.

4. Discrete Output Modules

- a. Discrete (digital) output (DO) module shall produce contact closure output (DO) signals to interface or operate equipment and devices external to the PLC module. The output modules shall be optically isolated from inductively generated, normal mode and low energy, common mode transients to 1500 volts peak and shall have IEEE surge withstand protection. Output modules shall have LEDs to indicate status of each output point. Each output point shall be individually isolated and fused.
- b. The discrete output modules shall have a maximum of 32 points each. If required, each of the module's output shall interface with an external and

separately mounted relay (interpose relay) that shall provide the dry discrete contact output. The output relay shall have a single form-C contact (one normally open and one normally close contact) with a minimum contact rating of 2-amp, 24 V DC, 10-amp, 120 VAC, or as required by the application. The failure of a single output relay shall require only the replacement of the relay and not the entire module. Failure of the module shall require the replacement of the module and not the relays. Relays shall be accordance with in Section 40 67 00 - Control Systems Equipment Panels and Racks.

5. Analog Input Modules

- a. This module shall accept 4 to 20 mAdc analog input signals. The module shall perform an analog to digital conversion where an analog to digital conversion is performed with 16 bit precision and the digital result is entered into the processor. New inputs shall be provided for every processor scan. The external 24 VDC power supply shall power the 4-20 mAdc 2-wire transmitters/ loops. Input modules shall be source or sink to accommodate 2-wire or 4-wire transmitters respectively. Analog input modules shall have 4, 6 or 8 differential inputs each and shall be isolated from each other.

6. Analog Output Modules

- a. This module shall provide for 4-20 mAdc analog signals output. Each analog output module shall have 4, 6, or 8 output points which shall be rated for loads of up to 1200 ohms. The module shall perform a digital to analog conversion with each scan of the processor and the analog result produced as an output. New outputs shall be produced on every scan. Analog outputs shall be isolated in the same manner as the analog input modules.

7. Remote I/O Adapter Module: Any PLC location, which requires more than one housing unit to mount all of the I/O modules, shall be supplied with an appropriate remote I/O adapter module for each secondary housing. The adapter module shall support all of the types of I/O modules required.

8. PLC and I/O Housings: The PLC, power supply, and I/O modules shall be mounted in suitable standard housings. Individual housing slots shall be mechanically configurable to prevent insertion of incorrect modules. Each new PLC location shall have empty I/O module slots to accommodate the required project growth requirements as specified above. The PLC shall also be provided with all the necessary mounting hardware, connectors, and cables. Filler plates shall be provided for unused slots in the PLC rack.

9. PLC Power Supply

- a. The PLC, I/O Modules and the analog and digital loops shall be powered by a single main external source of redundant set of 24 VDC power supply system, The redundant power supplies shall be configured in a fault-tolerant manner in order to prevent interruption of service upon failure and interruption of utility power or service necessitated by the replacement of a power supply.
- b. The 24 VDC power supplies shall have 120 V, 60 Hz input, a 24 VDC linear output, with +/- 0.05% line and load regulation. Power supplies shall be designed for parallel wiring of the 24 VDC output. Power supplies shall be power factor correcting and shall have short circuit and overload protection. Each power supply shall be sized at twice the initial connected load including slave and interposing relays.

- c. The power supply shall include diagnostic indicators to provide the operator with the status of the DC power applied and the redundancy. Each 24 VDC power supply shall also include status and fault LED indicators and a fault/redundancy status monitoring dry contact output. The fault status output contact of each power supply shall be wired to its own PLC digital input (DI).
- d. In cases when the CPU must be powered by a 120 VAC power source due to existing conditions or OWNER requirement, a 120 VAC 60 Hz power supply shall be provided and mounted in the PLC housing to power only the CPU and the I/O modules. It shall be sized to power the CPU and all modules mounted in that housing and an "average module load" for any empty housing slots plus the percent growth requirement specified above of that total. The 120 VAC power supply shall be by the same manufacturer as the PLC and shall be of the same product line.
- e. In all cases, the analog and digital loops shall be powered by an external redundant 24 VDC power supplies as specified above.
- f. The power supply shall monitor the incoming AC line voltage for proper levels and shall automatically shut down the PLC system whenever its output current is detected to be at improper levels. Power supplies shall have fuse protection. In addition, a means of disabling power to the CPU shall be possible from a power disconnect switch or fuse.

10. PLC Control System Software and Programming

a. General

- 1) The CONTRACTOR shall furnish the latest version, standard, field proven, fully debugged and supported PLC programming and diagnosis software package for this application with a minimum of additions or changes. Customized or specially written software shall be furnished if required to meet all of the functional requirements specified herein. Any custom applications software required shall be fully integrated into the basic software and shall not require unique command structures.
- 2) All programs shall be self-configuring, such that they obtain the size and configuration of the system from parameters contained in the various files created during system generation. No parameters related to the hardware configuration shall be hard coded into any of the software.
- 3) All programming, monitoring, searching, and editing shall be accomplished using this PLC programming software. The programming software shall be usable while on-line (connected to the PLC), or off-line. The PLC program shall display multiples of series and parallel contacts, coils, timers, counters and mathematical function blocks. It shall have the capability to disable/force all inputs, outputs and coils to simulate the elements of the ladder logic by means of color change. The software shall include a search capability to locate any address or element and its program location PLC status information, such as error indication and amount of memory remaining shall be shown on the display screen.
- 4) The PLC programming software package shall be able to monitor and/or control PLCs via the communication network. It shall contain diagnostics to collect troubleshooting and performance data and display it in easy to

understand graphs and tables. It shall also monitor devices at each drop on the communication link for proper communication.

- 5) The PLC programming software shall be able to generate a PLC program printout which is fully documented. Fully documented program listings shall have appropriate rungs, address, and coils shown with labels, descriptors and identifiers. Comments shall clarify to a reader what each segment of the program accomplishes. A fully documented listing shall also include a cross reference report of program addresses.
- 6) The PLC programming software shall run on Windows 7 platform. The programming language and format shall be IEC 61131-3 compliant and allow programming to use Ladder Diagram (LD), Sequential Function Chart (SFC), and Functional Block Diagram (FBD) programming languages.
- 7) The PLC shall be easily programmed with a laptop plugged into the controller. Programming functions shall be done both "on-line" while the processor is scanning, or "off-line." On-line programming and upload/downloads of control programs shall be able to be done over the Ethernet network.
- 8) Furnish a minimum of 3-user licensed copies of the PLC programming software registered to the Owner. The software shall be provided with all the options the necessary option to meet the requirements in these specifications.

2.2 OPERATOR INTERFACE TERMINAL (OIT)

- A. Manufacturers: The PLC and the OIT specified herein shall be IVC display/Hope System.
- B. Description: The CONTRACTOR shall furnish an Operator Interface units (OI's) and software for each PLC or as indicated on the drawings with the following features:
- C. Materials / Components:
 1. 12 inch (minimum) active matrix color TFT LCD monitor with touch screen controls. Resolution shall be standard SVGA (min 800x600 pixels) with 65,356 color graphics.
 2. Ports: Ethernet (IEEE802.3, 10/100 BASE-T), 2- USB, RS-232, RS 485
 3. Protocol Supported – Modbus TCP/IP, Modbus (serial),
 4. Memory – 32 MB flash EPROM, 512 Kb SRAM with battery backup, and slot for memory card.
 5. Power – 24 VDC
 6. UL Listed., NEMA 4x (indoor and outdoor application)
 7. Memory Card 128 MB
 8. Configuration and development software running on Windows 7 with password protection.

9. Software and Configuration - The OIT shall be configured to display simple graphics that include facility graphic similar to those displayed on the HMI. The OIT shall enable access to change operational set points in the PLC the operator access. Additionally, the OIT shall display process variables trending, and display/manage facility alarms. The software shall be of the same manufacturer as the OIT.

2.3 HUMAN MACHINE INTERFACE (HMI) HARDWARE

A. Description:

1. The contract documents shall present the various HMI node types required for the HMI system. A summary description of each node is provided below and in section 40 68 00 – PLC-Based Control System Software.
2. This Section covers the furnishing of standard HMI hardware fully installed and configured in the control system as specified herein. It is the intent of this Specification to have the CONTRACTOR furnish the latest standard, field proven, and supported PLC-based hardware for the PCIS.
3. All computer hardware shall be furnished with all necessary power supplies, processors, main memory, auxiliary and bulk memories and their corresponding drives, peripheral interface cards, auxiliary function cards, modems, cables, drivers, etc., to meet the functional requirements for the configured system as specified and as shown on the system architecture diagram.
4. All numeric specifications below (i.e., processor and speed, hard disk size, amount of RAM, etc.) are minimum values only. The CONTRACTOR shall propose equipment with higher performance specifications than those specified as new technology develops, is available and allows. Such proposals should be made to the OWNER and the ENGINEER at the pre-submittal/pre-construction meeting. The proposed equipment shall be field proven.

B. Materials / Components:

1. Dedicated Operator Workstation
 - a. Machine Type: Fan-less, disk-less industrial operator interface.
 - b. Operating System: MS Windows CE, ME or Pro platform
 - c. Specifications and Features: As recommended by the HMI application manufacturer to support the required control screens and I/O density.
2. Security Workstation
 - a. Machine Type: Desktop, multi-processor, multi-drive, graphic workstation grade computer.
 - b. Operating System: MS Windows Server platform or Pro platform dependent upon application demands (e.g. network monitoring applications). Note: A Pro-level platform is normally sufficient.
 - c. Specifications and Features: As recommended by the Security System application vendor to support the required control screens.

- d. Special Instructions: Application should be stored on Drive 0 with the OS. Application data should be stored on Drive 1.

2.4 LOCAL AREA NETWORK HARDWARE

A. Manufacturers:

1. The Ethernet managed switches shall be **by Phoenix Contact or equal.**
2. The Ethernet managed PoE switches shall be **by Phoenix Contact or equal.**
3. Network router shall be by **Cisco, or equal.**
4. Cellular gateway shall be **Cisco Catalyst, Moxa OnCell or equal.**
5. Communication Network Bridge – Multiplexer by **Modicon model BM85 (P/N NW-BM85-000), no equal**

B. Description:

1. Network devices shall be furnished and installed by the CONTRACTOR as detailed in this section and as shown and/or specified on the Architecture or Network Block Diagrams. Firmware modules, where applicable shall be installed. The network devices shall be of the latest revision. If the specified model has been, or is currently scheduled to be discontinued by the manufacturer, the CONTRACTOR shall furnish (with the approval of the ENGINEER) the manufacturer recommended replacement model of equal or better functionality, performance and reliability.
2. The CONTRACTOR shall also be responsible for configuring new and if applicable, the existing network hardware, verifying the firmware, adding communication modules (and other network hardware components as specified) and configuring the network modules to ensure successful working integration with the control system communication network per the contract requirements.

C. Performance / Design Criteria:

1. The new LAN hardware shall comply with the IEEE 802.3 standards for Ethernet and operate at a minimum bandwidth of 100Mbps.
2. The network topology shall permit either switched 100BASE-TX or 1000BASE-TX connections through an auto-negotiating switched hub.
3. Redundancy: The CONTRACTOR shall provide a managed, self-healing redundant Ethernet network configuration.

D. Materials / Components:

1. Network Switch
 - a. The CONTRACTOR shall provide an industrial type 24-port redundant Managed Ethernet Switch at each of the locations identified on the drawings. Each port shall provide a dedicated 100Mbps (200 Mbps in full duplex) connection between the switch and a node. Each port shall be auto-negotiating (speed and duplex mode) to allow for the fastest possible connection.

- b. The switch shall be configured per IEEE 802.1d Rapid Spanning Tree Protocol (RSTP) supporting Ethernet TCP/IP communication. The Managed Ethernet Switch shall be able to connect to industry standard fast Ethernet 100BASE-T or 100BASE-TX media type. There shall be a software protocol layer that uses TCP/IP as the transport mechanism to deliver packets of data to other equipment that use the same protocol.
- c. The switch shall have at least one medium dependent interface/medium dependent interface crossover (MDI/MDIX) configurable port and shall have memory dedicated for media access control (MAC) address storage.
- d. It shall be supplied with all necessary power supplies, connecting cables, and software as necessary to obtain the specified functionality.
- e. The switch shall be installed in a location such that no cable run to the server, workstations, printer, server, or fiber router exceeds 200 feet.
- f. Additionally the switch shall meet the following requirements
 - 1) Power Input- 24 VDC
 - 2) UL listed
 - 3) Din rail mount
 - 4) 30-percent of the ports shall be kept unused (spare)
- g. Managed ethernet switch shall be GeoVision model GV-APOE0811.

2. Network Router

- a. The CONTRACTOR shall provide industrial grade network routers as required by network architecture and application.
- b. The router shall be able to interface to different physical types of network connections, such as copper cables, fiber optics, or wireless. Each router shall have at least 16 ports supporting fast Ethernet 100BASE-T networks at a connection speed of 100Mbps.
- c. Router shall include firewall, VPN handling, and other security functions in order to provide high level of security especially when used in function that require remote access.
- d. The router shall be installed in location such that no cable run to the server, workstations, color ink jet printer, terminal server, or fiber router exceeds 100 meters.
- e. Each router shall be supplied with all necessary power supplies, connecting cables, and software as necessary to obtain the specified functionality.6.
Power input: 120 VAC

- E. Network Interface Cards: the CONTRACTOR shall provide all necessary network interface cards to reconcile protocols incompatibilities.

2.5 POWER SUPPLY (UPS)

- A. Provide and install line interactive UPS units where indicated and as specified on the Network Block Diagrams. Vendor Control Panel UPSs shall be supplied with the VCP.
- B. UPS shall back up the power for the Network Rack and PLC in case utility power fails. The UPS shall be a "smart" type, use on-line, high frequency, double-conversion technology. The batteries shall be integral to the UPS enclosure.
- C. Capacity and Duration: The continuous output capacity of the UPS shall meet the minimum KVA listed in the table above. It shall be sufficient to supply Process Control and Instrumentation system components including, but not limited to, the PLC panel and associated modules, operator interface terminals, radios, and instruments sub-fed from the PLC panel with regulated AC power for a minimum of 20 minutes from batteries only. The UPS shall provide for a 25% future load increase. Additional batteries or larger UPS size shall be provided to meet the specified backup time.
- D. The CONTRACTOR shall submit load calculations and size each UPS to justify the selection of present and future load requirements, as well as overload and inrush capacity requirements. UPS submittals shall include sizing calculations, which support UPS size selected and the battery size selected and detail projected battery life at 50% and 100% of maximum load at the average ambient temperature of the indicated installation environment.
- E. Where required to be separately mounted from the served equipment, the UPS units shall be mounted in 19" rack vented wall mount enclosures, suitable to house the UPS and extended battery module(s). Wall mount enclosure height shall accommodate 2U space, minimum, around the UPS. The enclosure shall be **Netshelter series by APC** or approved equal.
- F. The CONTRACTOR shall provide heat calculation for the selected equipment and the selected enclosure. Provide enclosure forced ventilation and cooling as needed to maintain UPS operating temperature below 100 degrees F.
- G. Under normal conditions the AC power line shall feed the UPS to power the protected load. The UPS shall also maintain the batteries in fully charged "float" condition. Whenever the normal AC power fails or dips below the normal range, the critical load shall be continuously supplied from the batteries and the double conversion system. The transfer from normal to AC line to backup power shall be bumpless and without a break in the output of the UPS (0 transfer time).
- H. Features and Options
 - 1. Input Power Range: 100 to 132 volts, 60 Hertz +/- 5 Hertz, auto-sensing.
 - 2. Output Power Range: 120 volt, +/- 3 percent of nominal, 60 Hertz +/- 0.5 percent.
 - 3. Output Receptacles: Minimum of six (6) NEMA 5-15R built-in outlets.
 - 4. Overload Capacity: The UPS shall have the ability to supply 110 percent of system requirements for 10 seconds, without degradation of the service life.
 - 5. Protection: The UPS output shall be protected (IEEE standards) from lightning, surges overload, and short circuit. The input shall be protected by a circuit breaker, sized in accordance with manufacturer's recommendations.
 - 6. Battery: Lead acid type, maintenance free, sealed suspended electrolyte, and leak-proof. Recharge Time (with half load): three (3) hours.

7. Bypass: Built in bypass
 8. Communications: Network Management card supporting Ethernet and USB ports and Modbus, HTTP and SNMP protocols.
 9. Alarms and Status: The UPS communications shall support monitoring of the health/status of the UPS and battery functions (i.e. UPS on battery power, low battery, battery high voltage, UPS fault, battery fault, battery disconnected, battery high temperature). Network Module shall provide UPS Status Webpage within the HMI SCADA control screens to provide information on the UPS for the Operator
- I. Manufacturer: **Schneider Electric-APC model SRT#####RMXLA-NC** (##### is the UPS size in VA).

PART 3 -- EXECUTION

3.1 FIELD QUALITY CONTROL

- A. The CONTRACTOR shall provide the OWNER with training on the subjects of use, maintenance, operation, troubleshooting and repair of all the components of the PLCs and the rest of the PBCS hardware. The training shall be specifically tailored to this project and reflect the hardware and the installation. All training shall be conducted on site unless another location is approved by the ENGINEER and OWNER. Hardware training subjects and the allocated hours for each class shall be in accordance with Section 40 61 00 - Process Control and Enterprise Management Systems.

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SECTION 40 67 00 – CONTROL SYSTEM EQUIPMENT PANELS AND RACKS

PART 1 -- GENERAL

1.01 THE SUMMARY

- A. General: The Contractor, through the use of a qualified and directly contracted System Integrator, shall provide control panels for the Process Control and Instrumentation System (PCIS), complete and operable, in accordance with the Contract Documents.
- B. The System Integrator shall be responsible for selecting, sizing, and furnishing the correct type and quantity of panels required to support the PCIS as detailed in the Contract Documents. Referencing the contract identified and applicable panel equipment, the System Integrator shall have design responsibility for:
 - 1. Sizing of panel equipment to meet load requirements
 - 2. Design of code compliant control and power circuits internal to the cabinet
 - 3. Location and mounting of panel interior and exterior instruments and hardware components
 - 4. Installation and labeling of field interface terminal blocks and patch panels
 - 5. Termination, labeling and managed routing of panel internal wiring and signals
 - 6. Panel and panel component grounding
 - 7. Panel component spacing, heating and cooling requirements
 - 8. Ensuring adherence to applicable UL codes and posted NEMA rating
- C. Package system control panels shall be designed, furnished, and factory tested by the package system Vendor.
- D. Contractor responsibilities shall include:
 - 1. Field installation of the System Integrator and Vendor furnished panels
 - 2. Termination of communication / network cabling, power conductors and field signal conductors at each System Integrator and Vendor furnished panel
 - 3. Execution of panel field testing activities

1.02 REFERENCE SPECIFICATIONS, CODES AND STANDARDS

A. Reference Specifications

01 33 00	Submittal Procedures
01 75 00	Equipment Testing And Plant Startup
26 00 10	Electrical General Requirements
40 61 00	Process Control and Enterprise Management Systems General Provisions

CONTROL SYSTEM EQUIPMENT PANELS AND RACKS

40 62 02	PLC Based Control System Hardware
Division 26	Electrical

B. Reference Standards

Underwriters Laboratories (UL)	
UL Standard 508A	Training on Industrial Control Panels
National Electrical Code (NEC)	
NEC Article 409	Short-Circuit Current Rating (SCCR)
National Fire Protection Association (NFPA)	
NFPA 79	Electrical Standard for Industrial Machinery

- C. All panels shall conform to the specifications, codes, and standards requirements detailed in Section 40 61 00 - Process Control and Enterprise Management Systems General Provisions, including:
1. UL Standard 508A
 2. NEC Article 409, short-circuit current rating (SCCR)
 3. NFPA 79
- D. The provisions of this Section apply to local control panels provided for equipment systems specified in other sections unless indicated otherwise in those sections.
- E. All panels shall prominently bear the certifying UL label and the NEMA/IP rating label after final assembly.

1.03 CONTRACTOR SUBMITTALS

- A. The Submittals shall be furnished in accordance with Section 01 33 00– Submittal Procedures and Section 40 61 00- Process Control and Enterprise Management Systems General Provisions.
- B. The Contractor shall submit a Control Panel Engineering Submittal (CPES) for each control panel furnished. The CPES shall completely define and document the construction, finish, layout, power circuits, signal and safety grounding circuits, fuses, circuit breakers, signal circuits, internally mounted instrumentation and SCADA system components, face plate mounted instrumentation components, internal panel arrangements, and external panel arrangements. All panel drawings shall, as a minimum, be "B" size with all data sheets and manufacturer specification sheets being "A" size. The submittal shall be in conformance with ISA-S20 - Standard Forms for Process Measurement and Control Instruments, Primary Elements and Control Valves, shall be submitted as a singular complete bound volume or multi-volume package within [120] calendar days after Notice to Proceed, and shall have the following contents:
1. A complete index shall appear in the front of each bound volume. Drawings and data sheets associated with a panel shall be grouped together with the panels being indexed by systems or process areas. Panel tagging and nameplate nomenclature shall be consistent with the requirements of the contract requirements.

CONTROL SYSTEM EQUIPMENT PANELS AND RACKS

2. Scale construction drawings which define and quantify the type and gauge of steel to be used for panel fabrication, the ASTM grade to be used for structural shapes and straps, panel door locks and hinge mechanisms, type of bolts and bolt locations for section joining and anchoring, details and proposed locations for "UNISTRUT" members, stiffener materials and locations, electrical terminal box and outlet locations, electrical access locations, print pocket locations, writing board locations, and lifting lug material and locations.
3. Scaled physical arrangement drawings drawn to scale which define and quantify the physical groupings comprising control panel sections, auxiliary panels, subpanels, and racks. Cutout locations with nameplate identifications shall be shown.
4. Front of panel layouts for all control panels.
5. Schematic/elementary diagrams shall depict all control devices and circuits and their functions.
6. Wiring/connection diagrams shall locate and identify electrical devices, terminals, and interconnecting wiring. These diagrams shall show interconnecting wiring by lines, designate terminal assignments, and show the physical location of all electrical and control devices.
7. Interconnection diagrams shall locate and identify all external connections between the control panel/control panel devices and associated equipment. These diagrams shall show interconnecting wiring by lines, designate terminal assignments, and show the physical location of all panel ingress and egress points.
8. Control sequence diagrams to portray the contact positions or connections required to be made for each successive step of the control action. Written descriptions explaining the control sequence diagrams and system operation shall be furnished.
9. Completed ISA S20 data sheets for all instrumentation devices associated with each control panel supplemented with manufacturer specification sheets which verify conformance to the requirements of the Contract Documents
10. A bill of materials which enumerates all devices associated with the control panel.
11. A priced listing of analog spare parts in conformance with Section 40 61 00- Process Control and Enterprise Management Systems General Provisions.

1.04 QUALITY ASSURANCE

- A. Factory and field tests shall be performed in accordance with Section 01 75 00 Testing and Plant Startup and Section 40 61 00- Process Control and Enterprise Management Systems General Provisions.

PART 2 -- PRODUCTS

2.01 GENERAL

- A. Environmental Suitability and NEMA Rating

CONTROL SYSTEM EQUIPMENT PANELS AND RACKS

1. Indoor and outdoor control panels and instrument enclosures shall be suitable for operation in the ambient conditions associated with the locations designated in the Contract Documents. Heating, cooling, and dehumidifying devices shall be provided in order to maintain instrumentation devices within 20-percent of the minimums and maximums of their rated environmental operating ranges. The Contractor shall provide power wiring for these devices. Enclosures shall be suitably rated for the environment in which it is to be installed. Panel instruments and equipment to be located in hazardous areas shall be suitable for use in the particular hazardous or classified location in which it is to be installed.
2. Control panels shall be designed and sized to adequately dissipate heat generated by equipment mounted in or on the panel.
3. For outdoor areas classified as general purpose, installed panel rating shall be NEMA 4X, 316 stainless steel construction. For indoor areas classified as general purpose (without washdown consideration), installed panel rating shall be NEMA 12, painted steel or 304 stainless steel construction unless otherwise indicated.
4. For outdoor chemical areas, selected panel material shall be chemically compatible with anticipated off-gassing constituents, UV resistant and securable.
5. Where indicated on the contract drawings, outdoor panels shall include 316 stainless steel sunshields fitted to all sides of the cabinet. Refer to installation detail I-940 for sunshield and sunshield stand-off requirements.
6. Every effort shall be made to avoid installation of equipment within classified areas. However, if required, implementation shall preferentially employ intrinsically safe (IS) equipment and circuits and/or inert gas purge and pressurization systems where possible. If use of IS circuits with supporting purge and pressurization system is impractical, installed continuous hinged panels shall have a NEMA 7/9 rating and constructed of materials impervious to the environment.

2.02 ENCLOSURES

A. Enclosures shall be as manufactured by:

1. **Hoffman**
2. **Rittal**
3. **Saginaw**

B. Materials / Components

1. Panel section faces shall be No. 12 gauge minimum thickness for free standing panels and No. 14 gauge minimum thickness for wall mounted or pedestal mounted panels. Materials shall be selected for strength, chemical compatibility, application, environmental considerations and specified project requirements.
2. Relay rack high density type panels shall utilize standard relay racks with No. 14 gauge steel frame and supports.
3. Structural shapes and strap steel shall comply with ASTM A 283 - Low and Intermediate Tensile Strength Carbon Steel Plates, Grade C.

CONTROL SYSTEM EQUIPMENT PANELS AND RACKS

- a. Bolting Material: Commercial quality carbon steel bolts, nuts, and washers shall be 1/2-inch diameter with UNC threads. Carriage bolts shall be used for attaching end plates. All other bolts shall be hex end machine bolts. Nuts shall be hot pressed hex, American Standard, heavy. Standard wrought washers shall be used for foundation bolts and attachments to building structures. Other bolted joints shall have SAE standard lock washers.

4. Construction:

- a. Dimensions shown on the contract panel elevation drawings are provided as reference only. Final enclosure dimensions shall be as determined by the Contractor to accommodate all components required plus spare. Elevations and horizontal spacing shall be subject to Engineer's approval.
- b. For Vendor packages, control panel dimensions shall be as per the Vendor's requirements.

C. Fabrication

1. End plates, top plates, and top closure panels (to hung ceiling) shall be provided when required by the material requisition. End plates, top plates, and top closure panels shall be removable with countersunk bolts to match panels. Top closure panels shall be furnished in lengths which match the widths of standard panels, except that one top closure panel may extend across two 4-foot 6-inch wide or five 2-foot wide standard panels. The vertical joints of these panels shall align with the vertical joints of the standard panels.
2. End closure or rear closure doors shall be provided where required. Such doors shall be flush fitting, gasketed with closed cell neoprene, and be of the hinged lift-off type with lockable door handles. A common key shall be provided for all doors on one panel assembly. Removable access panels shall be provided with dished handle fasteners. Screw driver 1/4 turn or Dzus type fasteners are not acceptable.
 - a. The flanged edges of all panels shall be straight and smooth. Corners and seams shall be welded and ground smooth.
 - b. The face of the panel shall be true and level after flanging.
 - c. All panel cutouts and holes may be cut or drilled by any standard method that does not cause deformation. Burrs shall be ground smooth.
 - d. Adjacent panels shall assemble with faces flush. Gaps or cracks shall not be visible from the front of the assembled instrument board.
 - e. Door and body stiffeners shall be provided where required. The stiffeners shall be welded to the inside of enclosures, as required, to prevent panel deformation due to the weight of face mounted instruments.
 - f. Panels shall be self-supporting as defined below.

D. Frameworks and Supports

1. The rear of each panel section shall have a steel framework assembled to it for supporting conduit, wireways, switches, piping, and instrument accessory items such as relay or terminal enclosures, transducers, pressure switches, valves, and air relays. The main framework shall be constructed of standard structural shapes. Special shapes such as "**Unistrut**" may be used for secondary supports. Framework must neither interfere with instrument connections nor interfere with access needed for maintenance or adjustments.
2. Steel framework shall extend 2-feet 4-inches back from the panel face or as indicated in the material requisition. Where indicated, individual adjustable leg supports shall be provided at the back of the framework so that the entire panel is self-supporting
3. The interior rear and sides of each enclosure shall have steel mounting channels for supporting mounting panels.
4. Enclosures shall be provided with external mounting feet, as well as door clamps, hasp and staple for padlocking, data pocket, and closed-cell oil-resistant gasket. Removable lifting lugs to facilitate handling shall be provided on large enclosures.
5. Back and Side Panels: Each enclosure shall be provided with a removable back panel. Depending on the size of the enclosure more than one back panel may be required. Removable side panels shall be provided as required for additional mounting space

E. Preparation of Panel Surface

1. The following requirements apply to the front and rear face of the panel, both sides and the edges of all flanges, and the periphery of all holes or cutouts.
 - a. High spots, burrs, and rough spots shall be ground smooth.
 - b. The surfaces shall be sanded or sandblasted to a smooth, clean, bright finish.
 - c. All traces of oil shall be removed with a solvent.
 - d. The first coat of primer shall be applied immediately.

F. Panel Finishing

1. Steel control panels shall be thoroughly cleaned, and sand blasted per Society for Protective Coatings SP 6 (Commercial Blast) after which surfaces shall receive a prime coat of **Amercoat 185H** or equal, 3-mils DFT, for a total thickness of the prime plus finish system of 6 mils. The finished color of the outside surfaces shall be selected by the Engineer, unless otherwise indicated. Interior of the control panel, back-panel, and side panels shall have a white finish coat.
2. A Thin coat primer surface shall be applied over the entire panel surface.
3. Wet sand, dry, then quick glaze spot putty on the front of the panel only. Dry, then wet sand again and dry
4. A primer surface shall be applied on the front of the panel only.

5. Wet sand to smooth clear finish, then dry.
6. At least 2 coats of air-dry, satin finish lacquer enamel shall be applied over the entire surface. Color to be as approved by Engineer.
7. Contractor shall supply 2 one-pint containers of air drying, matching paint for field touch-up of the panel face.
8. Non-stainless steel enclosures shall have an ANSI 61 gray polyester urethane powder coating electrostatically applied to inside and outside surfaces. Enclosure interior, and back and side panels shall be white

G. Finishing and Mounting of Instruments

1. The final coats applied to painted surface of instrument cases, doors, or bezels which are visible from the front of panels shall be manufacturer's standard unless otherwise indicated. Black Japan or "crinkle" finishes on instrument cases are not acceptable.
2. The panel vendor shall provide cutouts and shall mount all instrument items indicated to be panel mounted, including any instruments indicated to be furnished by other vendors but installed in the panel.
3. The panel vendor shall also mount behind the panels other instrument accessory items as required for functionality as indicated.
4. Equipment mounted at the rear of panel shall be installed to allow for commissioning adjustments, servicing requirements, and cover removal.
5. Spare space shall be kept clear of wiring, etc., to give maximum space for future additions
6. For front mounted hardware, cutouts and holes may be cut or drilled by any standard method that does not cause deformation. Burrs shall be ground smooth. Mounting the instruments shall not degrade the NEMA rating of the enclosure.
7. DIN rail mounted equipment shall be used whenever possible.
8. Installed enclosure equipment shall be provided with an interior nameplate to identify tag and function
9. Ventilation, Louvers, Vents, Filters and Heaters:
 - a. Heating, cooling, and dehumidifying devices shall be provided in order to maintain all instrumentation and control devices within the Manufacturer published operating range
 - b. In vented enclosures where excessive internal heat or internal moisture is a design consideration, the enclosure shall be equipped with filtered louvers and a thermostat controlled cooling fan. The perimeters of the louver plate shall be sealed with a gasket. Louver shall be of the same material and finish as the enclosure. The louver shall be sized for effective heat rejection.

- c. For unvented enclosures, cabinet shall be equipped with a thermostat controlled recirculation fan, positioned to move air across the critical control and communication components.
 - d. Thermostat controlled heater or heating strips shall be installed to prevent freezing of components and to mitigate condensation within the cabinet. Enclosure heater (120Vac) shall be as manufacturer by **Hoffman**.
 - e. Ventilation fan (120Vac) and filter kit shall be as manufactured by **Hoffman**, **Cooltron**, or Engineer approved equal.
 - f. Enclosure bi-metallic temperature switch shall be accurate to within ± 2.0 degrees Fahrenheit and shall be as manufactured by **Hoffman ATEMNC**, or Engineer approved equal.
10. Include additional panel accessories to meet the specifications, such as floor stand and mounting kits, door handle and lock kits (common key shall be provided for all doors), 3-point latch, and interior protective pocket to hold panel drawings.
- a. 3-point latching handles shall be as manufactured by **Hoffman**, **Powerglide** corrosion resistance model.

2.03 ELECTRICAL REQUIREMENTS

A. General Requirements

1. The main power supply to the control panel controls shall be 120 Vac, 60 Hz. Where the electrical power supply to the control panel is 240 Vac single phase or 480 Vac 3-phase, the control panel shall be provided with a control panel transformer. Control conductors shall be provided in accordance with the indicated requirements.
2. The control panel shall be the source of power for any field instrumentation loads, including solenoid valves, that are connected to the control panel
3. The main feeder disconnect shall have a door-mounted handle unless otherwise indicated.
4. Each source of foreign voltage shall be isolated by providing disconnecting or pull-apart terminal blocks or a disconnect operable from the control panel front. Each control panel shall be provided with identified terminal strips for the connection of all external foreign voltage. A "CAUTION - Foreign Voltage" nameplate shall be attached to the outside of the enclosure door warning of foreign voltages inside the enclosure. Each conductor associated with foreign voltages shall be yellow
5. The Contractor shall provide wireways, wire, and electrical fittings and components for 120V and 24Vdc circuits to instruments and other electrical devices in the panel for a complete and operable installation.
6. The circuits for 24Vdc shall run in separate wireways from the 120 Vac circuits
7. Conduit, wireways, junction boxes and fittings shall be provided for signal wire, thermocouple, or resistance thermometer lead wire. Conduit or wireway runs shall include those required between temperature sensors and temperature transmitters and between the thermocouple wireway or junction box and instruments.

8. Use of flexible conduit subject to the requirements of Division 26.
9. Conduit fittings shall be **Crouse Hinds cast fittings** or Engineer approved equal.
10. Each terminal connection shall have a plastic plate with a terminal and instrument tag number. Wiring shall be identified with stamped tubular wire end markers.
11. Freestanding panels shall be provided with switched, natural light, 60-watt equivalent LED light kit. Covered light fixture shall be provided for every 4-feet of panel width and shall be mounted inside and in the top of the back-of-panel area.
12. Freestanding panels shall be provided with a 15 amp, 120 volt, service outlet circuit within the back-of-panel area. The breaker protected circuit shall support one 3-wire, heavy-duty, industrial grade, duplex receptacle, installed every 4-feet of panel width (one minimum per panel), spaced evenly along the back-of-panel area. GFCI receptacle shall be as manufactured by **Hubbel, Leviton** or Engineer approved equal.
13. Wall mounted or pedestal mounted panels shall be so sized as to adequately dissipate heat generated by equipment mounted in or on the panel.
14. Wall mounted or pedestal mounted panels mounted outside shall be provided with thermostatically controlled heaters that maintain inside temperature above 40 degrees F.
15. Provide a hand switch controlled, natural light, 60-watt equivalent LED light kit and a breaker protected 120 volt, 15 amp, industrial grade GFCI duplex receptacle within each wall mounted or pedestal mounted panel larger than 4 cubic feet volume.

B. Wiring Methods - General:

1. The signal, control and power wiring specified herein shall apply only to wiring inside the control panel. Field wiring shall be in accordance with requirements specified in Division 26
2. Wiring methods and materials for all panels shall be in accordance with the NEC requirements for General Purpose (no open wiring) unless otherwise indicated.
3. Wire numbers shall be marked using white numbered wire markers made from plastic-coated cloth, **Brady Type B-500** or Engineer approved equal, or shall be heat shrink plastic. Wire numbers shall be marked on all conductors at every terminal connection and shall be readily identifiable without twisting the conductor

C. Control Wiring

1. Wire type and sizes: Conductor shall be flexible stranded copper machine tool wire, UL listed Type MTW, and shall be rated 600 volts. Wires for instrument signal circuits and alarm input circuits shall be No. 14 AWG.
 - a. 120 Vac Control Wires: No. 14 AWG machine tool grade type MTW, rated for 90 degrees C at dry locations, shall be as manufactured by **Southwire, Okonite**, or Engineer approved equal.

- 1) Refer to Power Wiring section for insulation color codes

CONTROL SYSTEM EQUIPMENT PANELS AND RACKS

- b. 24 Vdc power, status, alarm, and control wires: Minimum of 16 AWG or heavier as required, with TFFN/MTW insulation

1) The following insulation color code designations shall be used:

- a) Positive (+) – Blue
- b) Common (-) – Blue/White
- c) DC Ground – Green

D. Alarm Wiring:

- 1. Panel supplier shall install and wire alarms including annunciator cabinets, audible signal units, beacons, test and acknowledge switches, and remote logic units as indicated. Interconnecting wiring to panel mounted initiating devices shall also be wired by the panel supplier. The wiring from external initiating devices shall be provided by the Contractor. Where plug and cord sets are provided for component interconnection, the panel vendor shall harness and support the cables in neat and orderly fashion.
- 2. Discrete outputs from the control panel shall be provided by electrically isolated contacts rated for 5 amps at 120 Vac.

E. Signal Wiring

- 1. Analog and instrumentation signal wiring inside the panel shall be No. 16 AWG minimum, twisted shielded pair of stranded and tinned copper conductors rated at 600 volts. Insulation shall be color coded PVC/Nylon:
 - a. Black-white for 2 conductor cable
 - b. Black-red-white for 3 conductor (triad) cable.
- 2. Multi-conductor cables where indicated shall consist of multiple No. 16 AWG stranded and tinned copper conductors twisted in pairs, with 90-C, 600V fault insulation. Multi-conductor cables shall be sized to allow for 10 percent spare signal wire.
- 3. All analog and Instrumentation cables shall be composed of the individual conductors, an aluminum polyester foil shield, a No. 22 or larger AWG stranded tinned copper drain wire, and a PVC outer jacket with a minimum thickness of 0.047-inches.
- 4. Single pair, No. 16 AWG, twisted, shielded cable shall be **Belden Part No. 3090A, similar by Southwire**, or Engineer approved equal.
- 5. Single triad, No. 16 AWG, twisted, shielded cable shall be **Belden Part No. 3091A, similar by Southwire**, or Engineer approved equal.
- 6. Analog inputs and outputs shall be isolated 4-20 mA, 2-wire signals with power supply.

F. Power Wiring

1. Unless otherwise indicated, instruments, alarm systems, and motor controls shall operate on 120 volt, 60 Hz circuits. Power conductors shall be flexible, stranded, copper UL approved type wires, and shall be rated at 600 volts.
 - a. 120 Vac power wires: Main 120 Vac power wiring for distribution in the control panel (line, neutral and ground) shall be a minimum of 12 AWG, or heavier as required by the panel load, with THHN/THWN insulation.
 - b. Power conductors in branch circuits such as for lighting, receptacle, heater and thermostat, etc. shall be a minimum of 14 AWG also with THHN/THWN insulation.
 - c. Wiring for 600 volt class power and lighting shall be as manufactured by **Southwire**, **Okonite**, or Engineer approved equal.
 - d. The following insulation color code designation shall be used:
 - 1) Line Power – Black
 - 2) Neutral (grounded circuits) – White
 - 3) Power Ground – Green
 - 4) Ungrounded 120 Vac control circuit conductors (switched power) – Red
 - 5) Wires energized by 120 Vac source external to the control panel shall have yellow insulation
 - e. At a location near the top of the panel (or bottom), the panel fabricator shall provide terminal box connections for the main power supply entry.
 - f. Power supply switches for alarm units shall be 3 pole type, arranged to open both power circuits and alarm circuits. Each annunciator unit shall be equipped with a separate switch.
 - g. Instruments located on the same panel section and serving the same process unit may be connected to a common branch circuit from the power supply. The number of power distribution circuits depends on the circuit load as noted herein. A 15 amp, 2 pole circuit breaker shall be provided in each branch circuit unless specifically indicated otherwise. The circuit load shall not exceed 10 amp. The interrupting rating shall be 10kA or the maximum available fault current at the line terminal, whichever is higher. Different panel sections or different process units must not use common branch circuits. The circuit breakers shall be DIN rail mounted type with a manual Open-Close toggle switch. Control circuit breakers shall be as manufactured by **Square D**, **Allen Bradley**, or **Phoenix Contact**. Amp ratings shall be as required for the application and trip shall allow for inrush characteristics. Nominally, unless specifically indicated otherwise:
 - 1) 20-amp main circuit breaker for the 120 Vac control panel power supply and power distribution. Line side terminals shall be covered by a barrier within the panel.
 - 2) 5 amp circuit breaker for the duplex 15 amp, 120 Vac GCFI receptacle used for service and maintenance.

CONTROL SYSTEM EQUIPMENT PANELS AND RACKS

3) 15-amp circuit breaker for the heater, thermostat, and ventilation/recirculation fan.

- h. Each potentiometer type instrument, electronic transducer, controller, or analyzer shall have an individual disconnect switch. Disconnect switches shall have metal or plastic tags indicating instrument tag numbers. Individual plug and cord set power supply connections may be used without switches when indicated in the material specification

G. Grounding

1. Provide a ¼-inch by one (1)-inch copper grounding bus bar with multiple connecting terminals. The grounding bus shall be complete with solderless connector for one #4 AWG bare stranded copper cable and with tapped holes to accommodate ground connections from various devices in the enclosure. Provide ground connections for different gauge wires with shield connection clamps as manufactured by **Phoenix Contact**, or equal. Provide separate ground buses for power and instrumentation signals. The copper cable shall be provided by the Contractor and connected to a system ground loop.
2. Provide grounding strap between the enclosure and the enclosure doors.
3. Identify equipment grounding conductor terminals with the word "GROUND," the letters "GND" or the letter "G," or the color green.
4. Signal Grounding (24 Vdc): Terminate each drain wire of a shielded signal cable to a unique grounding terminal block or common ground bus at the end of the cables.
5. Ensure the continuity of the equipment grounding system by effective connections through conductors or structural members.
6. Design so that the removal of a device does not interrupt the continuity of the equipment grounding circuit.
7. Size ground wires in accordance with NEC and UL Standards, unless otherwise noted.
8. Connect all exposed, noncurrent-carrying conductive parts, devices, and equipment to the equipment grounding circuit.

H. Terminal Blocks

1. Terminal blocks (fused with blown fuse indicator and feed-through type as required) shall be as manufactured by:
 - a. **Weidmuller SAK Series KDKS**
 - b. **Phoenix Contact UK5 Series**
 - c. **Allen-Bradley Series 1492**

2. The control panel shall be provided with sufficient terminal blocks for the connection of external field conductors, signals, and power and for use inside the panel for power distribution and for future expansion. In order to facilitate easy and safe loop maintenance, each analog input loop shall have a fused disconnect with test plugs built into its field terminal block.
 3. Terminal blocks shall be positioned so that the internal and external wiring does not cross and with unobstructed access to the terminals and their conductors.
 4. Spare Terminal Blocks for Signals: The panel supplier shall provide sufficient spare terminal blocks to connect additional signals for future use (implemented and future spares). Implemented spare signals shall be wired to terminal blocks. The percent of these terminals shall be in accordance with the growth requirements specified in Section 40 62 02 – PLC-Based Control System Hardware. For future signals (i.e. the source of inputs or final control elements are not yet known or available in the field), the panel supplier shall provide 25-percent spare terminals in the panel for each type of actual I/O in the PLC. The number of terminals shall take into account the types of I/O for which spares are provided.
 5. Spare Terminal Blocks for Power and Other Applications: In addition to the spare terminals for signals, the panel supplier shall provide spare terminals for 3 additional power distribution and grounding applications circuits.
 6. Terminal blocks for all wiring shall be modular terminals, DIN rail mounted type (35 mm rail) rated for 30 amperes at 600 Vac and have a minimum width of 8-mm suitable for the specified stranded wire gauge. Terminals shall be the solderless box lug type with pressure plates in actual contact with the wire to minimize wire breakage. Each terminal shall have a light colored strip for marking the terminal number or circuit designation. Terminal identification shall correspond with markings on the drawings and shall be permanent, machine printed identifiers. Double high terminal blocks are not acceptable.
 7. External connections to and from enclosures shall terminate on terminal blocks, except approved communication and data cables, which shall terminate in patch panels as specified. Circuit isolating switches and fuse terminals shall include non-conducting pullers which can be removed by finger alone, without tools. Additionally, the panel shall be provided with identified terminal strips for the connection of external/field conductors.
 8. Wire duct shall be flame retardant plastic wiring duct, slotted with dust cover. Wire duct shall be as manufactured by **Panduit**.
- I. Circuit Breakers, Fuses and Disconnects
1. Circuit breakers, fuses and disconnects shall be installed in the control panel to protect against fault current from the 120 Vac and 24 Vdc branch circuits and the instruments and the electrical components that these circuits power. Circuit breakers shall be installed as disconnects of external power feeds for control circuits from outside the enclosure and branch circuits within the enclosure
 2. Each circuit breaker and fuse shall be identified by a service nametag.
 3. The fuses shall be mounted in a DIN mounted fuse holder terminal block and shall have a blown fuse indicator light. The holders shall have an LED indicator light and shall be **Ferraz Shawmut, Littelfuse, or Bussmann**.

CONTROL SYSTEM EQUIPMENT PANELS AND RACKS

- a. Provide a durable, readily visible label for each fuse, clearly indicating the correct type, size, and ratings
- b. Provide fuses that are rated for the voltage and available short circuit current at which they are applied.
- c. Provide UL listed Class RK1, dual-element, time delay fuses with the amp ratings as required for the application.
- d. Fuse holders shall be of the modular type, DIN rail mountable, and of a touch safe design with all terminals protected against accidental touch. The fuse holder shall incorporate the blown fuse indicator and shall have a nameplate that identifies each fuse. Approved manufacturers include **Weidmuller, Phoenix Contact or Allen Bradley.**
- e. A fuse, sized as required, shall be provided for the protection of each 24 Vdc branch (including spares) and equipment that is powered by the 24 Vdc power supply. Each analog and discrete input loop shall also be protected by a fuse. A fuse shall be provided to each instrument regardless if it is equipped with an integral replaceable fuse

J. Control Panel 24Vdc Power Supplies

- 1. Din-rail mountable, redundancy capable power supplies shall be as manufactured by:
 - a. **Sola**
 - b. **PULS**
 - c. **Phoenix Contact**
- 2. Control panels shall be provided with redundant power supplies which shall be configured in a fault-tolerant manner to mitigate interruption of service. The power supply shall convert 120 Vac to 24 Vdc
- 3. The panel supplier shall size the power supplies to meet the control panel load plus the field distribution power load supported by the panel. Field distributed power shall include any 24 Vdc two-wire or 4-wire field device, and any PLC controlled solenoid valves. One power supply shall be capable of supporting the full load with an excess rated capacity of 40 percent.
- 4. Power supply shall be UL508C listed to allow full rated output without de-rating.
- 5. The failure of a power supply or redundancy module shall generate a dry relay contact output that can be wired as a discrete input to the local PLC.
- 6. Power supplies shall be DIN rail mountable and of a touch safe design

K. Panel Surge Protection Devices

1. Surge protection devices (SPD) shall be provided for process control loops, field instruments, and field networks for protection against induced current surge and transient surge sources (e.g. lightning, power switching, static discharge, etc.). The SPD shall divert the resulting surges safely to earth and limit voltages to acceptable levels. Panel SPDs shall be as manufactured by:
 - a. **Emerson EDCO**
 - b. **Phoenix Contact**
 - c. **MTL / Eaton**
 - d. **Islatrol**
2. Each end of a loop shall be protected by an SPD - at the control panel side and at the field side instrument or device – as indicated on the P&IDs or the project instrument schedule
3. For hazardous areas, the SPD shall be certified to meet the hazardous area classification required for the environment in which it is to be installed.
4. Technical Data and Design:
 - a. The SPD shall be of the fast acting type, capable of limiting destructive high voltage transients, and accurately controlling voltage. It shall be maintenance-free and shall self-reset once the over voltage event has ceased.
 - b. The SPD shall be of a multi-stage hybrid circuit design, incorporating gas-filled discharge tubes (for high surge current diversion) with zener diodes for fast operation. It shall include the following features:
 - 1) Minimum withstand of 10kA at 8/20 μ s total surge current impulse per wire for all 24Vdc discrete and analog control panels interfaces.
 - 2) Minimum withstand of at least 1.4kA lightning impulse current at 10/350 μ s total surge current impulse per wire for all 24Vdc discrete and analog control panels interfaces.
 - 3) Housing shall be modular, 7mm maximum width, and of the DIN rail mount type for all 24 Vdc analog and discrete control panel interfaces. Field SPD shall have ½ NPT threaded connection and shall be housed in a NEMA 4X, UV resistant cabinet.
 - 4) Operating Ambient Temperature Range: -40°F to +176°F
 - 5) 120Vac discrete circuits shall be protected by 7mm maximum width DIN rail mount, metal oxide varistor (MOV) SPDs for control panel interfaces. Provide visual indication of MOV status on the input and output circuits.
 - 6) Field instrument SPDs shall be of the threaded conduit entry type with 20kA maximum surge current per wire. 7mm maximum width DIN rail mount units may also be used for 120Vac field instruments as specified.
 - 7) Range of voltage ratings to suit all process I/O applications.

- 8) SPD shall include screw type, cable-clamping terminal block to support wiring connections. The connections shall be gas-tight and the terminal blocks fabricated of non-ferrous, non-corrosive materials.

L. Nameplates shall be provided on each panel as indicated on the Drawings.

1. Provide in accordance with Section 26 00 10 – Electrical General Requirements on all internal and external instruments and devices.
2. Provide a nameplate with the following markings that are plainly visible after installation:
 - a. Panel Manufacturer's name, trademark, or other descriptive markings by which the organizations responsible for the panel can be identified.
 - b. Supply voltage, phase, frequency, and full-load current.
 - c. Short-circuit rating of the panel based on one of the following:
 - 1) Short-circuit current rating of a listed and labeled assembly.
 - 2) Short-circuit current rating established utilizing an approved method
3. For all panels, a nameplate shall be mounted on the enclosure door exterior and shall be engraved with the panel tag and description as shown on the contract drawings. (Nameplate material and sizing shall be as detailed in the Division 26 specifications)

M. Status Monitoring

1. PLC and remote IO cabinet components shall support status/alarm monitoring connection to the local PLC / RIO for display at the control system HMI. Component monitoring shall include:
 - a. Panel interior high temperature alarm switch
 - b. Panel intrusion switch (one for each door)
 - c. 24Vdc primary and secondary power supply status monitoring (as detailed in specification 17100-2.1-J).
 - d. Controller webpage monitoring (as applicable)
 - e. Air-conditioning unit fault status (as applicable)

N. Dimensions shown on the contract panel elevation drawings are provided as reference only. Final enclosure dimensions shall be as determined by the Contractor to accommodate all components required plus spare.

2.04 PANEL COMPONENTS

- A. Panel-mounted devices and panel internal electrical components shall be furnished in accordance with Division 26 specifications. Panel-mounted devices shall be mounted a minimum of 42-inches above finished floor elevation.

B. General Purpose Relays

1. General purpose relays in the control panel(s) shall be compact plug-in type with contacts rated 10 amperes at 120Vac or 24Vdc. Quantity and form of contacts shall be as required by the application.
2. In general, relays shall have a minimum of two form-C contacts (DPDT), except when used as an interposing relay for PLC DO modules. Interposing relays shall have one form-C contact (SPDT). Each relay shall be provided with an LED to indicate energized state.
3. The relay socket and mounting shall be a standard DIN rail mount with pullover wire spring ("horseshoe clip").
4. For all types of 120 Vac relays, provide surge protection across the coil of each relay
5. For all types of 24 Vdc relays, provide a free-wheeling diode across the coil of each relay.
6. Relays shall be **IDEC compact relays type RHXB-UL with SHXB-05 sockets** (where X indicates the number of form C contacts), or Engineer approved equal.

C. Interposing Relays

1. Additional interposing relays shall be provided when the number or type of contacts required exceed the contact capacity and/or rating of the specified relays and timers. Additional relays shall be provided when higher contact rating is required in order to interface with starter circuits or other equipment. Furnished interposing relays shall be as per the general purpose relays specified above.

D. Time Delay Relays - Electronic Type

1. Time delay relays shall be plug-in electronic type with on-delay or off-delay actuation as required. Output contacts shall be DPDT, rated for 10-amperes at 240Vac minimum. Each unit shall include an adjustable time delay with a time range scale. Operating temperature range of the units shall be -20 to +120 degrees-F. Each device shall be rated for 10,000,000 mechanical operations and 500,000 electrical operations.
2. Time delay relays shall be **IDEC RTE series or Allen Bradley type 700-HR series**.

E. Indicating Pilot Lights

1. Indicating lights shall be 30mm, ultra-bright LED, push-to-test type. Lights shall be of heavy-duty, oil-tight, corrosion resistant, weather-proof construction suitable for outdoor installations. Each light shall have a screwed-on prismatic lens approximately 1-inch in diameter. Miniature style devices are not acceptable.
2. Unless specifically noted otherwise, lens colors shall be assigned as follows:
 - a. Red for Start / Run / Opened / On / Failure
 - b. Green for Stop / Closed / Off

- c. White for Status Normal or Powered condition
 - d. Amber for Alarm Active
- 3. Provide hazardous location type pilot devices for classified locations
- 4. Indicating lights shall be **Schneider Harmony 9001K**, or equal. Each pilot light shall have a factory-engraved legend plate, as shown on the Contract Documents.
- F. Selector and Pushbutton Switches:
 - 1. Selector switches and pushbuttons shall be rated 10A at 600V; shall be of heavy-duty, oil-tight, weather-proof construction; and shall include the number of required contacts as shown on the contract or Engineer approved wiring schematics.
 - 2. Miniature style devices are not acceptable.
 - 3. Pushbuttons shall be 30mm type. Lever-type switches shall be furnished as indicated on the P&ID panel elevation drawings
 - 4. Switches shall be **Schneider Harmony 30mm 9001K**, or equal. Each switch shall have a factory-engraved legend plate as shown on the Contract Documents. Furnished switches shall be self-grounding.
- G. Signal Splitter
 - 1. Signal splitters shall be capable of generating two identical 4-20mA isolated outputs from a single 4-20mA input. Each input and output channel shall operate independently and shall employ galvanic isolation to prevent interaction, formation of ground loops and reduce noise. The units shall automatically compensate for load resistance variations from 0 to 1000 ohms. Current output shall be limited to 27mA.
 - 2. Signal splitters shall be as manufactured by **Acromag Model 633T**, or equal
- H. Signal Converter / Isolator
 - 1. The current-to-current converter/isolators shall accept a 4 - 20 mA input signal and provide a linear current output signal proportional to the input signal. Unit shall be operated from 120 V power and shall be by **Acromag, Phoenix Contact, or Moore Industries**.
- I. Current Transmitter
 - 1. The current transmitter shall be a 4-20ma loop powered device rated from 0-10 amps to 0-600amps. Transmitters for motors 50hp and smaller shall be solid core; transmitters for larger sized motors shall be split core. For DC currents, the transmitter shall utilize a Hall Effect sensor with signal conditioner to measure the potential difference of the detected magnetic field. For AC currents, the transmitter shall utilize an inductive sensor with signal conditioner to measure the current produced by the expanding and collapsing magnetic field. The transmitter shall output a 4-20mA signal proportional to the sensor current measuring range.
 - 2. The transmitter shall be **NK Technologies AT1 series**, or equal.

J. Digital Indicators

1. Digital process indicators shall be self-contained instruments that display process signals directly in engineering units. The unit shall be suitable for panel mounting and shall utilize a 3-1/2 digit LED display of no less than 0.5-inch height. The input signal to the digital process indicator shall be 4-20 mA DC or 1-5 Vdc as indicated. The input sample rate of the unit shall be a minimum of 2 per second. The unit shall have an auto-zeroing feature and shall have provisions for field adjustable scaling and offset. The indicator's setting shall be lockable to avoid accidentally change by unauthorized personnel. Accuracy shall be plus and minus 1 least significant digit. Input power to the digital indicator shall be 120 Vac, 60 Hz.
2. Digital process indicators, with NEMA 4X housing where specified, shall be as manufactured by **Precision Digital, Red Lion** or equal

K. Loop Controllers

1. Type: Proportional plus-reset plus derivative process controllers shall be microprocessor based single loop controllers.
2. Features: Units shall have front panel bargraph and digital indicators with scales in engineering units as indicated. Fully adjustable high and low process alarm setpoints shall be provided as indicated. Alarm outputs shall be indicated on the front panel of the device. All accessories required for adjustment of control parameters shall be provided.
3. Functions: Process controllers shall include manual-automatic control selection, fully adjustable proportional plus-automatic reset plus-derivative mode(s), bumpless transfer switching, setpoint control and indication, output high and low limiters, and controlled variable and output signal indicating scales. Controllers shall accept 4-20 mA input signals and provide a similar resultant output signal. In the event of power loss with a controller in either automatic or manual mode, all controller settings shall return to the previous value after power is restored. Proportional band setting shall be fully adjustable from 3 percent to 500 percent. Controllers shall include manual increase and decrease pushbuttons. Reset rate shall be fully adjustable within 0-6 repeats per minute. Controllers shall include anti-reset wind-up feature and a reset disable feature. Derivative time shall be fully adjustable from 0.05 to 8 minutes. Controllers shall have the implemented capability for disabling the derivative function. Designated controllers shall include a remote setpoint feature including a remote/local selector switch. Remote setpoint input signal shall be 4-20 milliamperes.
4. Accuracy: Vertical process and setpoint bargraph indicators shall have an accuracy of plus and minus 0.5 percent of span.
5. Size: Enclosures shall be nominally 3-inch by 6-inch suitable for separate or multiple panel mounting.
6. Operating Environment: The units shall be suitable for operation in indoor environments with ambient temperatures between 40 and 120 degrees Fahrenheit and over a range of 10 to 90 percent relative humidity.
7. Power: Controllers shall operate on 120Vac, 60 Hz. Power supplies, if required, shall be provided.

8. Manufacturers, or equal:
 - a. **Yokogawa YS1500**
 - b. **Red Lion DLC**
 - c. **Or Engineer approved equal.**

L. Component Nameplates

1. Nameplates shall be provided for instruments, function titles for each group of instruments, and other components mounted on the front or the inside of the control panel. A nameplate shall be provided for each instrument and device. The nameplates shall be descriptive to define the function and system of such device in accordance with the Contract Documents or the approved shop drawings. Adhesives shall be acceptable for attaching nameplates, however stainless steel nameplates shall be fastened with screws. Nameplates shall be fabricated from white-face, black-center, laminated engraving plastic for devices within the panel and stainless steel for instruments.

PART 3 -- EXECUTION

3.01 PREPARATION

A. Preparation for Shipment and Shipping

1. Control panels shall be crated for shipment using heavy framework and skids as required, and cushioned to protect the finish and the instruments during shipment. Shipments shall be by air-ride vehicle. Suitable cushioning material shall be used to protect interior hardware that could be damaged due to mechanical shock.
2. Depending on panel size, each separate panel unit shall be provided with removable lifting lugs to facilitate handling.
3. Control panels shall be installed in accordance with Section 40 61 00 - Process Control and Enterprise Management Systems General Provisions.

3.02 INSTALLATION

A. Wiring Installation

1. Wiring methods and materials for panels shall be in accordance with the NEC requirements and industry practices.
2. Wires shall be run in plastic wireways except (1) field wiring, (2) wiring between mating blocks in adjacent sections, and (3) wiring from components on a swing out panel to components on a part of the fixed structure.
3. Wire shall be neatly grouped using nylon tie straps, and shall be fanned out to terminals. Wiring run from components on a swing out panel to other components on a fixed panel shall be made up in tied bundles. These bundles shall be tied with nylon wire ties and shall be secured to panels at both sides of the hinge loop so that conductors are not strained at the terminals.

4. Wiring run to control devices on the front panels shall be tied together at short intervals with nylon wire ties and be secured to the inside face of the panel using adhesive mounts.
5. Splicing of wires shall be kept to a minimum and only if the wire cannot be replaced. Splicing shall be either soldered or pressure crimped type. Data and communication wires/cables shall not be spliced.
6. Wire nuts shall not be used.

B. Wiring Termination

1. All field wiring shall terminate at a terminal block in the enclosure. Field wiring shall be terminated first at the field interface terminal block and then wired to the devices/instrument or PLC inside the panel. In general, field wiring shall not be wired directly to the panel mounted device. Fiber cables, copper communication cables and field bus cables should be managed by patch panel or marshalling module unless specifically indicated otherwise on the contract drawings.
2. Terminals and fuses for each conductor and shield drain wire of a twisted shielded pair or triad cable shall be mounted consecutively next to each other.
3. Terminal blocks shall be grouped based on their function and voltage. Each group of terminal blocks shall be located in the panel to provide easy access and to minimize internal wiring.
4. Terminal blocks for control signals (24Vdc or 120Vac) shall be grouped separately from the power terminals blocks (24Vdc or 120Vac)

- C. Each terminal and wire connection shall be tagged in accordance with the approved shop drawings or the OWNER'S standard tagging/numbering, if available.

D. Conduit Penetrations

1. Conduit penetrations in cabinets installed outdoors or areas subject to washdown shall be made on the bottom or side of the panel, never through the top unless authorized by the Engineer in writing.
2. Gaskets and sealing material shall be installed at each conduit cutout as required.

3.03 CALIBRATION, TESTING, AND INSTRUCTION

1. General: Calibration, testing, and instruction shall be performed in accordance with Section 40 61 00 - Process Control and Enterprise Management Systems General Provisions.

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SECTION 40 68 00 – PLC BASED CONTROL SYSTEM SOFTWARE

PART 1 -- GENERAL

1.1 THE SUMMARY

- A. The CONTRACTOR, through the use of the System Supplier shall furnish, install, assemble, configure, program, and place into service all PCIS and PLC hardware and software as a complete, integrated and functional PLC based SCADA and communication system to perform the functions specified in the CONTRACT DOCUMENTS.

1.2 REFERENCE SPECIFICATIONS, CODES AND STANDARDS

- A. Section 40 61 00 – Process Control and Enterprise Management Systems General Provisions
- B. Section 40 62 02 – PLC Based Control System Hardware
- C. Section 40 67 00 – Control Systems Equipment Panels and Racks
- D. Applicable Sections in Division 40 – Instrumentation and Control for Process Systems
- E. Division 26 – Electrical
- F. Division 27 - Communication
- G. The PLC-based control systems hardware, programming software, software installation and programming, and other work related to the PLC-based control systems shall conform to the specifications; codes and standards requirements specified Section 40 61 00 - Process Control and Enterprise Management Systems General Provisions.

1.3 ACTION SUBMITTALS / INFORMATIONAL SUBMITTALS

- A. Software Submittals: PLC Based Control Systems Software submittals and Operation and Maintenance Manual(s) shall be in accordance with the requirements specified in Section 40 61 00 - Process Control and Enterprise Management Systems General Provisions.

1.4 QUALITY ASSURANCE

- A. PLC-based control systems software manufacturer's representative services shall be provided in accordance with Section 40 62 02 – PLC Based Control System Hardware.

1.5 WARRANTY

- A. Guarantee and Special corrections of defects and software upgrade requirements and warrantee shall be in accordance with Section 40 61 00 - Process Control and Enterprise Management Systems General Provisions.

PART 2 -- PRODUCTS

2.1 GENERAL

- A. The application software shall be the latest versions of **Intellution iFix, Indusoft** running on the latest updated version of Microsoft Windows operating system.
- B. The CONTRACTOR shall provide standard and customized software, fully installed and configured for the process control and instrumentation system (PCIS). The software the CONTRACTOR provides shall be the latest generation, field proven, fully debugged and supported software package for this application.
- C. Software is described in broad, functional categories. The System Supplier shall furnish a complete software package including the functional requirements along with whatever additional software is required for proper and efficient operation. Customized or specially written software that is commercially available shall be furnished if required to meet all of the functional requirements indicated. Any custom applications software required shall be fully integrated into the basic software and shall not require unique command structures.
- D. The software package shall provide a system capable of controlling system level functions, and a higher level process control language allowing the operator to monitor and control the process through an interactive HMI. The software environment shall support a multiprogramming atmosphere allowing concurrent execution of more than one program in a background/foreground mode or multi-tasking mode.
- E. Throughout the execution of all software modules, the operator shall be presented with all of the command or operation choices available at that point in the program using sufficient verbiage or symbols to make the choices self-explanatory and unambiguous. Question and answer or fill-in-the-blank requests shall only be permitted where tag names, or other unique text or numerical information is required.
- F. Workstations and nodes accessing the central computer system shall be supported by the same software at the central computer.

2.2 PLC PROGRAMMING SOFTWARE

- A. The PLC programming software is specified in Section 40 62 02 - PLC Based Control System Hardware and shall be provided under that section. However, the integration of the PLC software into the PLC Based Control System Software shall be part of and in accordance of this section.

2.3 HUMAN MACHINE INTERFACE (HMI) - STANDARD APPLICATION SOFTWARE PACKAGE

- A. General:
 - 1. The standard application HMI software package shall be a standard fully developed, field tested/proven, and commercially available product. It shall be a real-time multi-tasking process monitoring and control software application. The software modules, as described below, shall be able to and provide for the collection, manipulation and storage of real-time data, necessary for:
 - a. Display, reporting data and events, and historical record keeping functions and in a format appropriate for its use and function.

- b. Communication to remote PLCs for the collection data and transmitting control commands.
 - c. Issuing automatic and operator initiated control commands; manual manipulation of the data base; and the retrieval and use of historical data.
2. The HMI software package shall be capable of and support:
- a. Control interface redundancy to ensure high availability of operations and maintenance of process/process equipment monitoring and control tools at all operation levels.
 - b. Full-redundant hot-standby configuration between the I/O servers.
 - c. High resiliency and calibrated availability of management suited business and regulatory analysis tools.
 - d. Package systems' dedicated operator interface (operating independent of and in parallel with the plant control system HMI) ensures availability of at least one interface.
 - e. Management level remote desktop client workstation allowing management level operators to assume full control of any facility for scheduled periods or on a permanent basis.
 - f. Remote access web-based clients.
 - g. Maintenance web-based clients allowing maintenance level staff to actively monitor any site and work in parallel with management or facility staff to troubleshoot process control issues and evaluate response to critical alarm conditions.
3. On-Line Configuration: The software shall be capable to perform on-line system configuration while the system is operating. Modifications shall include adding, deleting and/or modifying database definitions, operator displays, PLC configuration, control strategies, and reports without having to interrupt the data acquisition.
4. Source code modifications, re-assembly, or recompilation are not acceptable.
5. System Size: The system software shall be provided in different sizes to meet various application needs. Ideally, the sizes would be for tag counts of 5,000, 10,000, and 30,000 and no limit for systems with I/O attached. As a minimum, the number of tags shall be the same number of total PLC I/O count, including spares.
6. The system shall provide complete user documentation, including examples of how to operate the various modules within the system. An on-line "help" facility, based upon Windows standard. Help menus, tutorials, and error codes and/or messages shall be provided.
7. Software Distribution: The software function specified may be performed by the PLCs, the central computer, or an off-line computer depending on the specific function. Certain portions of each software module may be specified to be performed by a specific machine, or inherently required to meet the functional aspects of the specified performance. Functions not specified as to location of performance may be performed at the location normally utilized by the software manufacture's standard software design. In any case, the distributed software shall

function as one integrated package to meet the overall requirements of the system. By virtue of the software distribution, the software shall also support a distributed type control system.

8. Multiuser Operation: The HMI shall support a multi-user operating system without any modification to the operating system(s) native code, while creating a true client/server environment that embodies the following attributes:
 - a. All features and graphics on server application can be made available to remote client. Client nodes, under authorization from the server node, shall have the ability to control as well as view the real-time data originating from the server node. All access rights and privileges shall be administered from the server only.
 - b. The HMI software shall support Thin Client architecture, whereby a client machine will be able to access the application software graphic displays for monitoring and control without requiring additional full application software to reside at the client machine.
 - c. Any changes to the application can be administrated solely from the server node and do not require corresponding changes at the client node(s). For example, additions and/or modifications to graphic displays at the server shall be automatically propagated to the client nodes. No separate graphics configuration tools shall be required for the client nodes to access server data.
9. Software Updates: All software shall be updated with the latest service packs and/or patches unless the update is not compatible with or not supported by other integrated software in the system. The update, if available from the software manufacturer, shall take place as necessary during the project construction period: at least during initial system configuration, prior to the factory acceptance test and during system packages and start-up prior to the 30-day final acceptance test.

B. Primary and Secondary SCADA I/O Servers

1. Required Operating System for the server(s): MS Windows Server platform (recommended) or Pro platform.
2. HMI software shall run on Windows 10 operating system.
3. The basic function of the primary I/O server is to function as an HMI communication interface to PLC units. The server shall poll the I/O addresses of each PLC while servicing user request interrupts. The server shall also support data transfer to the various client workstations.
4. The secondary I/O server shall be identical to the primary server and shall backup the HMI communication interface to PLC units. In the event of a failover, the backup server shall be capable to poll the I/O address listing of each PLC while monitoring the status of the primary server. In the event of a primary server fault or primary server application fault, the secondary server will be immediately elevated to primary server status.
5. The HMI application software should be stored on Drive 0 with the Operating System (OS). Application data shall be stored on Drive 1.
6. The I/O server and the software shall perform the following functions:

- a. HMI to PLC communication
 - b. HMI to Historian communication
 - c. Configured for hot-standby failover
 - d. Detect the following faults to auto initiate failover:
 - 1) Gateway/driver/communication module failure (e.g. OPC Server watchdog timer active/inactive).
 - 2) Application failure
 - 3) Loss of server or server communication link
- C. Redundancy and Failover: The two I/O servers shall be configured in a full-redundant hot-standby configuration connected and configured via local area network. The servers shall be identical in hardware and software to provide one server as the backup to the other. Server may be optionally configured as default primary OR established as the primary server until fault or manually forced to secondary status. In either case, server should be configured to continuously collect data in parallel with the secondary server.
- 1. Under normal conditions the on-line (primary) server shall perform data collection, and all the normal monitoring, control, alarming, archiving, and reporting functions. The configuration shall keep the off line (secondary/backup) server updated in the event of failure of the primary computer and so that the OWNER will be able to access the off line server for all operational functions. The system shall keep track of which server is the primary and which is secondary server.
 - 2. In the event of the primary server failure the configuration shall provide an automatic bumpless switchover to the secondary server. There shall be no data loss due to the immediate transfer from the primary on-line operating server to the secondary server upon and the collection of data shall proceed uninterrupted.
 - 3. Network laptops shall be able to connect to either of the two servers, and shall be capable of adjusting set points, acknowledge alarms (alarms shall be acknowledged once at either machine), etc. through that computer. If the primary computer fails, the user on the network computer shall be notified to reconnect/re-log to the other computer. This reconnection shall be manual.
- D. Stand Alone Configuration
- 1. Without Networking: In non-networked applications, the software shall be capable of performing all desired functions (data acquisition, graphics, trending, reporting, etc.) within a single computer.
 - 2. Adding a Network: Should the OWNER elect to network the computers at a later time, all that shall be required is to connect each computer to the local area network, and enable the networking functions within the software. Neither reconfiguration nor duplication of database tags shall be required to make data available to other nodes that require access to it.
- E. Data Management
- 1. General

- a. The server software shall provide an application independent data storage and analysis tool capable of receiving, selectively storing, analyzing , repurposing and then selectively forwarding re-formatted data to any (and multiple) database driven application. Application should include high density data support (scalable for the life of the facility) integral reporting functions, graphic webpage generation, reduced-packet data transport, multi-protocol support and redundant server resolution support.
 - b. No programming, compiling or linking shall be required to configure the system. The database tags must be configurable on-line. The new function and database tag assignments shall be added while the system is performing data acquisition and control operations.
 - c. The process database containing the current value of the data, or tag list, shall be memory-resident and of a design that is appropriate for real-time monitoring and control functions. Its design shall be optimized for speed, memory usage, and data integrity and system security. Floating-point arithmetic shall be used in all calculations.
2. Data Integrity: The software shall provide pre-emptive multitasking to ensure that common Windows actions do not interfere with I/O communications, processing of data, alarming, and the integrity of the real-time and historical data.
3. Database Tag Configuration
 - a. Various input/output hardware assignments, as well as processing functions, shall be assigned to named tags or "function blocks". Multiple tags may be tied together to perform more complex functions. During the configuration process, the program shall be capable of checking the tag structures for correct linkages, appropriate names, and so on. The scan processing program shall also be capable of detecting and handling configuration errors at run-time. Any errors encountered shall generate messages to the user.
 - b. Configurations that are not attached to I/O and do not contain tags shall also be available. These systems shall be available with 2 types of rights to a tag: with rights to read and write to tags in other nodes, and with rights to only read tags from other nodes. These rights can be controlled by the developer using security.
 - c. The user shall be able to perform tag configuration such as adding, modifying, deleting, and viewing.
4. Database Tag Types
 - a. Analog Data Base: A comprehensive data base shall be furnished for the analog inputs, calculated values, control modules, and outputs. In addition, spare data base points shall be provided for future expansion. All portions of the data base shall be available for use by the display, report, and other specified software modules. In addition, spare data base points shall be provided for future expansion to match the PLC spare I/Os and as specified.
 - 1) Blocking: It shall be possible to inhibit or block the scanning and/or processing of any analog input through the central computer. For any input so blocked, it shall be possible for the operator to manually enter a value to be used as the input value. The blocked value shall be maintained at the PLC.

- 2) Linearizing: Where analog inputs require square root extraction or other linearization, means shall be provided at the PLC to condition the filtered data before the process of scaling and zero suppression take place.
 - 3) Scaling and Zero Suppression: A conversion program shall be provided to convert input values into engineering units in a floating point format. This function shall be performed at the PLC.
 - 4) Alarms: An alarm program shall be provided to check all analog variables against high-high, high, low and low-low alarm limits. When an analog value exceeds a set limit, it shall be reported as provided for under "Alarm and Status Reporting" based on individually set priority level for each alarm point. There shall be an adjustable hysteresis band in order to prevent excessive alarms when a variable is hovering around an alarm limit. Return to normal shall also be reported. This function shall be performed at the PLC, including alarm and acknowledge status.
 - 5) Averages: Averages shall be continuously computed, and have a selectable time period and shall be performed at the PLC.
 - 6) Totals: The PLC shall calculate totalization of analog variables. There shall be a scaling factor assignable to each variable to convert to the appropriate units based on a selectable interval.
 - 7) Control Modules: For each control function configured whether processed at the PLC, there shall be maintained a file of necessary data including input values, set points, constants, output value and limit clamps, etc. Input and output assignments, set points, and constants shall be adjustable by the operator through the central computer. Control algorithms shall provide for manual control and output values shall be adjustable by the operator as described under "Control Functions" below.
 - 8) Calculated Values Means shall be provided to allow for pseudo-inputs calculated by algebraic and/or Boolean expressions utilizing real inputs, other calculated value, constants, etc. These values shall be handled the same as real inputs in terms of record keeping, alarming, etc. The calculated values shall be performed at the PLC.
 - 9) Real-time Trend: This tag shall take as its input an analog or calculated value. Averaging of accumulated input values will be provided to extend the amount of time represented by the trend block. The data within the tag can be graphically depicted on operator displays.
- b. Digital Data Base: A comprehensive data base shall be furnished for the digital inputs, calculated points, control logic, and outputs. In addition, spare data base points shall be provided for future expansion to match the PLC spare I/Os and as specified. All portions of the data base shall be available for use by the display, report, and other specified software modules. The digital data base software shall support the following functions and attributes:
- 1) Blocking: It shall be possible to inhibit or block the scanning and/or processing of any digital input through the central computer. For any input so blocked, it shall be possible for the operator to set the state of the input. The set value and its block value shall reside at the PLC.

- 2) Status and Alarm: Each digital point shall be assigned a priority level for change of state reporting as provided for under "Alarm and Status Reporting" below. It shall be possible to set different priority levels for change of state in one direction as opposed to the reverse direction. Alarm and acknowledged status shall be maintained at the PLC.
- 3) Totals: The PLC shall calculate and store run time and number of start totals of digital inputs. At the end of each totalizing period, the totalized values for the period shall be stored for historical records and the totalization register shall be reset to zero. There shall also be provided a non-resetting (lifetime) run time and number of start totalizer functions.
- 4) Digital Outputs: Digital outputs shall be maintained as part of the data base. Software shall be provided to allow for single (two state) and dual (three state) output types. Output change of state shall be reported as described for inputs above. It shall be possible for outputs to be set manually by the operator through the central computer or automatically through control logic and sequences.

5. Tag Attributes:

- a. Each tag shall have an instrumentation tag name of up to 30 characters. The name shall be alphanumeric. All other application programs shall use this tag name as their sole reference to the data element assigned.
- b. Scan rates shall be able to be set independently for each appropriate tag. Longer scan rates of up to once per 24 hours shall also be supported.
- c. Alternatively, the user may elect to have tags processed on an exception basis. This choice shall be allowed on a tag-by-tag basis.
- d. Also, any input tag may be configured as a "one-shot". This will cause it to fetch the value from the I/O device just one time when the system is started or the tag is brought on scan.
- e. Each tag associated with a hardware address or capable of causing an alarm condition shall have a means of displaying a descriptive message on the alarm printer. The descriptor shall be at least 40 characters in length.
- f. For tags assigned to actual hardware points, they shall also contain fields for:
 - 1) Hardware device name
 - 2) Hardware address
 - 3) Hardware specific parameters
 - 4) Signal conditioning requirements

6. Database Packages:

- a. SQL (Structured Query Language) Package. This package shall consist of 2 database tag-types, the SQL Data and SQL Trigger. It shall utilize Microsoft's Open Database Connectivity (ODBC) for connection to the external ODBC-compliant database.

- b. The SQL package shall support ANSI SQL commands to facilitate database reporting requirements. These commands shall be generated by the system without requiring the user to explicitly know or write SQL code. Provisions shall exist for users to modify existing SQL queries to satisfy additional reporting needs. It shall be possible to generate a set of standard reports from the collected and logged data, for use, as a minimum, to summarize logged data for data analysis. It shall also be possible to print and/or store in the computer any reports generated.
 - c. Control package: This package shall include standard functions such as PID, Lead/Lag, Ratio/Bias, ramp, on/of, signal selector, high/low etc.
7. Database Logging: Database: logging shall be supported for defined system points for configured system events. Database logging shall support relational database connectivity for commercially available database such as Oracle, and ODBC compliant systems. The architecture shall execute SQL commands for the pertinent read/write operation. The system shall implement the database-logging scheme to permit configuration without users being required to write SQL type commands. In addition, the system shall support database logging to the extent that table, row, column, index and stored data are user definable in accordance with the following and permit setup without written SQL commands:
- a. Table definition: The system shall support a table or schema definition of the selected relational database management system (RDBMS). This table definition or template shall be reusable for other table structures. Data types supported for column definition shall include small integer, integer, float, character, and date formats. Data formats may vary depending upon selected RDBMS.
 - b. Data Ordering: The system shall support data ordering via sequence number or equivalent for logged data. Data ordering sequence shall be definable in the schema definition for the data table.
 - c. Data Indexing: The system shall allow indexing for stored data in any data table. Multiple indexing shall also be supported.
 - d. Database connections: The system shall support multiple database connections for read/write operations. As a minimum, 10 database connections shall be supported. Database connectivity through the above relational databases shall support a local or remote database connection as supported by the system to support enterprise connectivity.

F. Communication

- 1. General: Server software shall be capable of providing efficient and secure data transfer between the servers and peripherals, and other terminals. The system shall support communication with a variety of external input/output (I/O) devices. The devices that can be interfaced to the system shall include:
 - a. PLCs: interface via network, radio, PLC manufacturer-supplied interface cards.
 - b. Remote I/O.
 - c. Intelligent controllers and equipment (e.g. smart starters, etc.).

2. Scanning and Communication Features: Communications software shall include the following features and capabilities:
 - a. Display-only Communications: To facilitate more efficient communications with PLCs, the system shall be able to provide display-only communications. Communications to read or write tags (Analog Registers and Digital Registers) will only be established when a graphics display containing these tags is open. When the display is closed, communications will cease.
 - b. Communication Ports and Drivers: The system shall be capable of simultaneously supporting different types of communications drivers and network ports. The communication drivers shall be configurable on-line.
 - c. Interrupts: All communication ports shall employ interrupt techniques to reduce polling overhead.
 - d. Buffering: All communication ports shall be fully buffered.
3. Communication and Data Error Detection and Recovery:
 - a. Communications between the servers and the PLCs shall include error checking codes and schemes to assure a probability of erroneous message acceptance. These error checks shall include lost response (time-out) and data error.
 - b. All messages shall be acknowledged to indicate that they have been properly received. Failure to receive a message acknowledgement shall cause the message to be retransmitted. The number of retries shall be user definable. If a proper reply is not received within the set number of tries, a communications failure alarm shall be generated.
 - c. Should communication errors be detected, the software shall automatically indicate that the data is no longer valid, and shall replace the invalid data with other characters. The system shall automatically attempt to re-establish communications, and, if successful, shall then replace the characters with valid data. These capabilities shall be built-in to the software and shall not require any user programming or other actions to implement.
 - d. Failover to a user-configurable back-up port shall be provided as a standard function of the driver. This capability shall, cause the software to automatically attempt to establish communications between the computer and the I/O device via the second communication port when it has determined that the connection via primary communication has failed.
 - e. Diagnostics: The system shall provide a diagnostic program capable of running on-line or off-line that can monitor message rates from the communication program. The diagnostic will display the number of new messages, retries, time-outs, and any occurrences of error. For serial drivers, a built-in datascope shall be provided. This datascope function shall allow the user to observe the messages being sent between the computer and the I/O device.
4. Communication Protocol and Scanning of Remote Sites
 - a. The server shall scan the PLCs in a sequential polling basis using the performance criteria stipulated in Part 3 - "Execution" - of this Section. The CONTRACTOR shall provide the means to set up a polling priority scheme where

various sites can be poled at a different frequency. The poling scheme shall be programmable and coordinated with the OWNER during construction.

- b. I/O Driver Toolkit: A toolkit must be available which will allow the creation of I/O drivers by end users, system integrators, and others.

G. Graphic Displays

1. The graphics package shall provide a means of creating and displaying color graphic displays of data, control and monitoring tools, and reports that will be used by the operator to monitor and control the process. Real-time values being read from the field devices shall be capable of being displayed in a variety of user-configurable formats. There shall be no limit (other than physical memory storage size) to the number of displays that can be developed and accessed on-line.
2. The development and runtime graphics packages must both be multi-document architecture applications with the capability to each support up to 10 open displays simultaneously.
3. The displays specified in the EXECUTION portion of this specification section shall be configured by the System Supplier and delivered with the system in complete operational form. Additional displays shall be configured on-line during the acceptance test period.
4. The graphic display program shall provide for the general attributes and display types listed below.
 - a. The system shall provide an interactive object-oriented editor that allows creation of graphic displays.
 - b. A facility shall be provided that quickly toggles between the graphic building and graphic runtime modes to speed display animation verification during the development process.
 - c. The software must be designed with the ability to make changes to the graphics while the system is running. Shutting down the system shall not be required to make changes.
 - d. Color Support: The graphics package shall provide support for an unlimited choice of colors with 256 colors supported at any one time. The user shall have the ability to create, save, and restore custom color palettes.
 - e. Graphic Toolbox: The system shall have a configurable graphic toolbox that the graphics developer can customize as to what tools it contains and change their position in the toolbox. Once configured, the state of the toolbox shall be automatically saved when the drawing session is completed. It shall be returned to that same condition when the next drawing session is started.
 - f. Graphic Animation: Each display must have the ability to dynamically update elements in the picture. Defining the method for dynamic update shall be determined by a point and click operation.
 - g. Paging: It shall be possible to page from one page to another related page using a vector "poke point". Alternatively, a display menu paging system may be employed.

- h. Point Displays: For each analog and digital input, calculated/control point, and outpoint there shall be provided a point display. These displays shall have a standard format for each point type and shall show all data pertinent to each point (point number, name, I/O address, filter and scaling factors, calculation, alarm limits and priority, set points and tuning constants, scan status, operational status, etc.). An operator shall be able to modify a configured point on-line through the point display.
- i. Alarm Summary Display: Provisions shall be made for an alarm summary display as described under "status and alarm reporting" herein.
- j. Graphic (Free Form) Displays: The graphic or free form displays shall allow for any combination of text, data (real-time updated), symbols, geometric shapes (lines, arcs, rectangles, eclipses), bar graphs, and vector "poke points" to be displayed on the screen. It shall be possible to tie any of these items to a point in the data base to allow it to change color, size, value, etc. in response to changes in the data base. Additional details relative to symbols, use of color, data base interface, etc. are presented herein under "Display Editor".
- k. Trend Displays: Trend displays shall be provided to allow data to be presented in a trend or strip-chart like format. It shall be possible to trend both live and historical data as defined below. Each defined trend shall be capable of displaying at least four variables. Each trend variable shall be displayed in its own unique color, including its engineering range/scale and time line values. It shall be possible to define an engineering range/scale for a trend that is different than that of the point's defined range/scale.
 - 1) Live (Real Time) Data Trend: It shall be possible to select any and all points in the data base for trending. A separate trend file shall be maintained for all points so selected. The trend time interval shall be individually selectable by the operator.
 - 2) Trending shall be able to display data from a combination of databases. A single chart shall be able to display pens from multiple databases simultaneously.
 - 3) Historical Trend: The Historical Display package shall have a multi-document architecture. It shall be possible to define a trend display from the historical data base and display it in a graphic format. The display of archived data shall be user-configurable.
 - 4) Historical trend windows must be able to update with newly collected data at time intervals, as selected by the user.
 - 5) For these trends it shall be possible to define the end point for each trend program as the present point in time or any other time, and/or date and period. It shall be possible to retrieve the live data trend file for analysis (see live data trends above).
 - 6) The historical trend display shall be made up of a pen group, time group, and legend group. The display shall support up to 8 variables to be displayed simultaneously. For each entry the operator will be able to assign a given tag name and marker to a particular line color selected from a palette of 256 colors.

- I. Operator Interface: Software shall be provided to allow the operator to perform control selection, manual control, and acknowledgement function interactively through the screen displays. It shall be possible to perform these functions through an interactive window. It shall be possible to call the window by positioning the cursor, mouse pointer on a symbol or data field that is tied to a data base point and pressing a single key or clicking. The type of equipment item or data point called will determine the exact operation that can be performed but, in general, provisions shall be made to allow for control mode selection (manual, local auto, central auto), manual mode commands (start, stop, etc.) alarm acknowledgements, set point adjustments, interlock resets, and totalizer resets.
5. Display Editor: The display editor shall allow for the creation of new displays and the editing of existing displays. The editor shall also provide for saving these screens to the system screen data base as new or replacement screens in a manner that allows them to be called by the operator utilizing the methods specified under "displays" above. The editor program shall operate on-line with the monitoring and control program, and in the background. The program man/machine interface shall be interactive in nature and shall provide prompting through menus (or similar device) from which appropriate selections can be made. As a minimum, the editor program shall provide for the following functions and features:
 - a. Select Edit Mode: When the editor is first started (and at other appropriate times as required) the program shall allow for selecting the editor mode. The available selections shall include (as a minimum) NEW, LOAD, EDIT, SAVE and QUIT.
 - b. Select Edit Function: When the edit mode is first selected (and at other appropriate times as required), the program shall allow for selecting the edit function. Available selections shall include (as a minimum) ADD, DELETE, COPY, RESIZE, and MOVE.
 - c. Select Symbol: After an edit function has been selected (and at other appropriate times as required), the program shall allow for a specific symbol to be added. Available symbol groups shall include (as a minimum) GEOMETRIC SHAPES, EQUIPMENT SYMBOLS, ALARM SYMBOLS, TEXT, DATA, BAR GRAPH, TREND GRAPH, and VECTORS. A library of objects shall be included with the standard product.
 - d. Assign Symbol and Object: It shall be possible to assign any symbol that has been selected to any attribute of any point contained in the configured data base. Status and alarm data points and attributes shall allow for color changes and alternative message displays. Analog data points and attributes shall allow for (one) dimensional change and actual numerical value display. Assignments shall be through menu selection. It shall also be possible to tag equipment "out-of-service" and display it on the screen. Objects may be assigned more than one dynamic property. In addition, objects within groups may have individual dynamic properties in addition to those dynamic properties assigned to the overall group.
 - e. Select Color: It shall be possible to set the color of a symbol for each possible state of the data base point that the symbol is assigned to, or to a fixed color if the symbol is not assigned to a data base point. It shall also be possible to set the background color and intensity. The normal color uses shall be either standard application software colors already used. Colors for the operational and status functions and other symbols will be determined by the OWNER.

- f. Graphic Refresh Rate: The refresh rate shall be user-definable.
- g. Sources of Data for Object Animation: The animation of the graphics and objects with dynamic properties shall be able to be linked to any types of data.
- h. Reusing Graphic Objects and Displays: A method shall be provided for allowing graphics objects or groups of objects to be re-used easily. In cases where the system has multiple similar displays the displays shall be able to be used as a template and later customized for reuse purpose.
- i. Tag Groups: The system shall provide a method of grouping tag names in a file such that specific tag names are provided to a generalized display.
- j. Automated Picture Generation: Displays shall be able to be generated automatically by importing the re-usable graphic objects into pictures.
- k. Multimedia Capability: Support for standard Windows multimedia capabilities, including audio and video, shall be provided.
- l. Documenting Graphic Displays: Printing of graphic displays in color and black and white shall be supported via the standard Microsoft Windows Print Manager in both the graphics development and runtime environments.

H. Alarms and Status Reporting

1. General: Software functionality shall be provided for the detection and reporting (alarming) of any change in the state of a digital input or the change of pre-determined value limits of analog variables. Detection and reporting shall also be provided for operator entered commands, deviation from control set points, watchdog timer reset, and modifications to the system operating parameters. The alarm conditions shall be detected even if the variables causing alarms are not currently on the display.
2. Alarm Configuration
 - a. Alarm messages shall be independently user-configurable as to what information is provided and its sequence within the message. The following shall be available choices:
 - 1) Time of the alarm
 - 2) Name of the tag causing the alarm
 - 3) Alarm condition code
 - 4) Engineering units value when the alarm occurred
 - 5) Descriptor text assigned to the tag
 - 6) Engineering units of the tag
 - b. Alarm limits shall be entered initially by the user at configuration time or from the operator's display during run-time. Changes to alarm limits or conditions shall be able to be entered at any time afterward by the OWNER. Alarm limits are expressed in engineering units.

c. Alarm Priorities and Filters

- 1) Each alarm and status point shall be assigned a priority level to indicate how that point is to be reported. The system shall support at least three (3) alarm priorities for each alarm type as listed below. A filtering mechanism shall be provided so that the operator can adjust the system alarm priority. Special alarm messages (such as I/O failure) shall be able to be masked
 - a) Priority 1 - highest level - shall require acknowledgement and cause the audible alarm to sound. Operator entries shall be considered Priority 1.
 - b) Priority 2 – medium - changes shall require an acknowledgement, but shall not cause the audible alarm to sound.
 - c) Priority 3 - lowest level - status changes shall not require acknowledgement nor cause the audible alarm to sound.
 - 2) The alarm summary display must provide sorting and filtering capabilities. The user shall be able to filter on node name, alarm area(s), alarm status and alarm priority. The user must be able to sort on time, tag, alarm area, alarm priority and alarm status.
- d. Alarm Counters: There shall be a built-in method that keeps track of the current number of alarms in various categories: These values shall be available to be used as display information or to create actions, such as setting outputs.

3. Alarm Display, Notification and Acknowledgment

- a. An alarm summary display (multiple page as necessary) shall be provided to allow the operator to view the points presently in alarm and all status messages received. The alarm summary display shall be a pre-defined dynamic link within the graphics package. This alarm summary display must show a list of the new and pending alarms in the system. As new alarms are detected, entries are made to the display list. As the alarm conditions clear, the entries are removed from the list.
- b. The display shall provide for at least 100 messages arranged in chronological order with the most recent alarm being at the top of the first page.
- c. Each display point shall include data as for the historical record. Through the use of color and blink function, the display shall discriminate for each point based on an alarm or return to normal status, and whether the alarm has been acknowledged.
- d. When a new alarm condition is detected, an alarm message shall be generated and shall flash until the alarm is acknowledged. The operator shall be able to acknowledge each alarm received through the alarm display. Beeping the computer's speaker when an alarm occurs and silencing the sound when acknowledged.
- e. An alarm notification shall be accompanied by beeping the computer's speaker. Alarm acknowledgement shall silence the sound.

- f. The system must be capable of "freezing" the highest alarm status value on the display until acknowledgment is made. Once acknowledgment is made, the system will display the current alarm status text.
 - g. The operator shall have the ability to purge the alarm display of data no longer required. A "purge" shall remove from the display all operator commands and inputs, all acknowledged status change messages, and all alarm messages that have been superseded by a later message. It shall be possible to print the alarm display on demand.
 - h. When an alarm is acknowledged from any node on the network, the acknowledgment shall be made directly at the node from which the alarm was generated, and a message indicating that it has been acknowledged shall then be distributed to all alarm destinations.
 - i. Messages shall be able to be designated as "events-only". These will be distributed to alarm destinations, but shall not require acknowledgment.
4. The software shall provide built-in capabilities to support the following additional alarm functions:
- a. Alarm Color Code: Ability to specify the color codes to indicate the various alarm conditions.
 - b. Remote notification and acknowledgment
 - c. Alarm suspension
- I. Archiving, Retrieval and Reporting
- 1. The system must provide a facility for automatically collecting, storing in a mass storage server (see HISTORIAN in this section), and recalling data. Recalled data will be made available to a trend display program, a report generation program and to user-written programs
 - 2. Archiving and retrieval shall be performed automatically (periodically), on demand, or in an interactive manner whereby the operator shall be able to select which files or group of files would be copied. All archiving and retrieval functions shall be performed on-line, including reading to or writing from a server.
 - 3. Data File Handling
 - a. Data will be stored in Windows-compatible files in compressed format. Compression will be performed through a user-supplied deadband. Entries containing time, name, value and status will be made in the file whenever the real-time value exceeds the previously-stored value by the deadband limit. A deadband value of zero will cause an entry in the file each time the real-time value is examined.
 - b. Files shall be organized according to time and will contain values for multiple, named variables. The file can be placed on the hard disk or a floppy disk, and can be placed on a file server if LAN server software is installed.
 - c. A mechanism for on-line maintenance and automatic purging of files must also be provided.

4. Reports:

- a. Software shall be provided to allow for the automatic (periodic) or on-demand printout of pertinent real-time and historical data in set report formats. The reports specified in the EXECUTION portion of this specification section shall be configured by the System Supplier and delivered with the system in complete operational form. Additional reports shall be configured on-line during the acceptance test period using the report editor program.
- b. Report Editor: The on-line report editor shall allow for the creation of new reports and the editing of existing reports. The editor shall also provide a method for saving these report formats to the system report format database, including the report print schedule. The editor program shall allow for free form typing of fixed text and data fields to set the format. This shall be followed by a listing that specifies the associated data base point (and attribute) or calculation to be performed for each data field.

J. Control Functions

1. The computer system shall be capable of performing control and logic functions both at the PLCs and the central computer. Local control, logic, and interlock functions shall be performed at the PLCs whereas system-wide functions shall normally be performed at the central computer. Specific control functions to be implemented under this contract shall be as specified under the "EXECUTION" portion of this Section and the Drawings. General control capabilities shall be as follows:
 - a. Control Configuration: Software shall be provided to allow control strategies to be developed and their operation initiated through the central computer system. Standardized control point displays shall allow for defining the control functions including the function type, input/output addresses, set points and tuning constants, etc. In a similar manner, it shall be possible to link separate control functions together into an integrated control strategy. It shall be possible to download operational/control set points developed in the central computer to a PLC for operational implementation. It shall also be possible to define and implement operational/control set points locally at the PLC and to upload them to the computer for operation record keeping.
 - b. Operator Control: All programming commands related to changing system configuration or controlling field devices shall be performed only through the PLC system, and shall require more than one keystroke to protect against inadvertent operations. The PLC system configuration commands shall require operator confirmation of a requested action before any change is made. This shall apply to changes in the algorithms, control sequences, and similar configuration related actions, as well as file copy and file delete commands. If any sequence requiring operator conformation, the operator shall be able to cancel the operation at any point prior to executing the command.
 - c. Operator Interface: The operator shall have access to and the ability to alter control parameters such as set points, tuning constants, time delays, etc. as well as the ability to select between local automatic, central, and manual control modes and to perform output manipulations in the manual mode. All such operations shall be capable of being performed through the central computer but shall be maintained at the PLC. Additional operator interface functions are described under "GRAPHIC DISPLAYS". Software shall be provided to allow

the operator to perform control selection, manual control, and acknowledgement function interactively through the screen displays

K. Security Management

1. The software shall provide a user-based password security system to prevent unauthorized personnel access to system operations. The security system must allow for the creation of users with certain rights and/or privileges. These rights must include the ability to run any combination or all of the applications in the data acquisition system. The ability to allow or disallow users' access to change values, such as set points and machine-setups, on an individual tag basis shall be supported.
2. Groups of users, such as operators or supervisors, can be created and granted rights. All users assigned to a group obtain the rights of the group, although they are still tracked by the system by their individual ID. Individual members of a group may also be assigned additional rights.
3. Each person in the group shall be assigned a password and security level. Passwords and users should be able to be randomly selected by the OWNER at run-time without interrupting the SCADA System. When an operator logs on, the security access shall be set at the level assigned to that operator.
4. The security system will support either centralized or distributed security file management.
5. The security system shall employ and generate an audit trail that will tag every operator action with user identification (ID).

a. Security Areas

- 1) The system must support separate security areas. Security areas shall be assignable on a per tag basis. Each tag can be assigned all of the available security areas, none of the available security areas, or up to 3 individual security areas. Only users with clearance for those security areas shall have the ability to change parameters.
- 2) Security area names may be up to 20 characters in length.

b. Security Manager: The following functions must be supported within the security manager application:

- 1) Enable/Disable user-based security
- 2) Define users, passwords and login names
- 3) Define groups to which users may belong
- 4) Define security path(s)
- 5) Define user and/or group rights/privileges
- 6) Define security area names
- 7) Define system auto-start user

6. In order to prevent unauthorized personnel to operate an unattended workstation, the security program shall have a "timer" that will automatically log off the authorized logged operator after 15 minutes from the last key stroke or mouse activity.
7. There shall be at least eight (8) security levels including the minimum levels listed below (lowest to highest). The security levels shall be able to be configured in any combination and also be extended to 16 modes.
 - a. View Level: At the view level, an operator shall be able to view all display screens and request reports, but all other available privileges, such as control, configuration, or make any other functional changes to the system, shall be denied/blocked. On initialization, the system shall default to the view level shall be blocked.
 - b. Operate Level: At the operate level, an operator shall be able to initiate commands (pump start/stop, etc.) and adjust set points and similar control parameters, but shall not be permitted to perform system configuration functions.
 - c. Engineer and Supervisor Level: At the engineer or supervisor level a person shall be able to perform all functions provided for in the software. This shall include the setting of operator security levels.
 - d. Class Based Security: A class based security scheme shall be inherent to the system allowing for Multiple View Levels, Operate Levels, and Engineer and Supervisor Levels. This scheme makes it possible for two operators to have the same level but mutually exclusive access to certain functions.

2.4 HMI NODES

- A. The CONTRACT DRAWINGS presents the various HMI node types. A summary description of each node is provided below.
- B. Historian
 1. The Historian server shall collect and archive data that is passed from the SCADA I/O server. The Historian shall examines the data received and compares against predetermined archive requirements (e.g. priority, preset sampling period, collection offset deadband, exception deviation since last read, etc.) prior to data archival. The Historian serves as data source for trending applications and reporting functions which may be integral to the Historian application or a separate reporting software module.
 2. The historian shall provide multi-level and synchronized historical data collection systems and authorized domain user access flexibility. The collection task can be run at any one or more computers on the network. The task shall have the ability to access data from the memory-resident tag list in its own computer and/or any computers on the network.
 3. All status changes and operator inputs shall be stored in the Historian for historical record keeping. The record shall include the time of occurrence, the point identification, the status/alarm (or return to normal) message, the present value for analog alarms, and the previous and entered value for parameter changes. Provisions shall be made to maintain at least 1,000 records.

4. For system that has a Historian at multiple locations (e.g. plants and headquarters, etc.), collected data is passed from the low hierarchy Historian to a higher level Historian.
5. The Historian shall communicate to the SCADA I/O Server using OPC communication protocol (continuous update).
6. The data synchronization between the I/O server and the Historian synchronization should occur in parallel with the real-time data collection. In cases where a system has more than one Historian, Historian to Historian synch, the data synchronization should commence immediately but re-prioritized during scheduled update periods per vendor recommendation.
7. Historian shall have scalable fault-tolerant storage and redundant OPC communications to support redundant local SCADA I/O server arrangements (i.e. the local Historian will automatically establish communications with the active (primary) SCADA I/O server)
8. The Historian must be capable of receiving out-of-synchronization data and re-ordering for storage in chronological order.
9. The Historian shall include default MS Excel link to support minimum reporting capability. However, a more robust, OPC compliant, web-capable reporting application should implemented to support enterprise level inter-operability.
10. Historian server should be configured to support web-based clients'.
11. In the event of communication loss, the following Historian functions should be available
 - a. Loss of communications (following a pre-set number of failed retries) should result in generation of a low-level system alarm
 - b. In the event of storage overflow at the SCADA I/O server, the earliest data written should be the first to be over-written.
 - c. Upon recovery of the storage Historian and its communication module, communication should be automatically established to all data sources and systematic query and data synchronization executed.
12. Machine Type: Rack-mount multi-processor, RAID 1 multi-drive, server grade computer (spec as recommended by the HMI application software vendor to support the required control screens and I/O density). Application should be stored on the RAID 1 drives with the OS. Collected data should be routed to the scalable NAS (Network Attached Storage) RAID 6 storage device. Additional system backup and appropriate media shall be per OWNER's procedures.

C. Dedicated Operator Workstation

1. Function: This workstation shall provide an industrial operator interface with full or minimal operating system and embedded and limited I/O HMI application and logging capability. The dedicated operator interface should only include control screens, fixed trends and alarm management functions customized to support a specific package system or equipment grouping.

2. In cases where field control panels include an operator interface, the operator interface may be implemented using a panel-mounted industrial workstation (employing a full OS installation) or ruggedized OS panel display. If used, the operator interface shall be linked to the plant as a client node or configured to independently interface with the local controllers. Where established as a dedicated device, the interface may serve as a primary or only graphic access point for a package system. Devices that cannot be monitored or secured shall not be used.

D. Engineering Workstation

1. Function: The engineering workstation is a programming workstation. It shall be equipped with the HMI software run-time development license for centralized development, modification and testing of controls screens.
2. The workstation software shall run on MS Windows Server platform or Pro platform dependent upon application demands (e.g. network monitoring applications). Note: A Pro-level platform is normally sufficient.
3. The Engineering Workstation, shall provide the following functions:
 - a. Develop, modify and test graphic control screens, trends, and reports.
 - b. Provide access to in-package and extended graphic symbol/object/gif libraries.
 - c. Develop, modify and test HMI level I/O databases (as applicable), functional code, web pages, workflow triggers and supporting material.
 - d. Modify tagging structures, tag groups, alarm groups/definitions, etc.
4. The Engineering Workstation shall be provided with:
 - a. PLC programming software and PLC simulation software for testing. Include support for auto PID loop-tuning tools.
 - b. Support for server and system monitoring and analysis tools as may be recommended by the HMI vendor.
 - c. Control system network monitoring and analysis tools as may be recommended by the software manufacturer for troubleshooting and system analysis.
5. Machine Type: Desktop multi-processor, multi-drive, graphic workstation grade computer Application should be stored on Drive 0 with the OS. Application data should be stored on Drive 1.

E. Full Client Workstation

1. Function: Full client workstation is a workstation with HMI client application and custom control screens installed locally. The client workstation shall display and allow authorized operator navigation of control screens with integral signal/status data continuously updated from the active I/O server. The client workstation shall also provide authorized operator access to trending display/ad-hoc development software, reports display/ad-hoc development software and view access to other HMI manufacturer furnished analysis / monitoring tools.
2. The workstation shall provide secured access to all I/O server monitoring/control screens and historical data. Authorized users shall have view access to previously

generated and archived reports as well as active trends. However, trend and report development capabilities will be limited to creation of new ad-hoc trends and creation of new ad-hoc report templates for manual generation only. Modification of existing trends and reports shall not be possible from the client workstation.

F. Remote Desktop Workstation

1. Function: This workstation shall have a MS Pro platform with active MS remote desktop manager (Terminal Services). With invocation of a remote desktop session (via pre-configured shortcut), access at the facility HMI full client workstation will be suspended. Encrypted desktop access re-routed to the remote desktop workstation thereby allowing application access (equal to the rights of the logged-in user) as though seated at the facility workstation.
2. The remote desktop workstation operating system should be configured to support multiple remote desktop sessions up to the recommended maximum by the HMI software manufacturer
3. Remote desktop access shall be coordinated and pre-arranged by the OWNER and should be secured to specific machine/user group combination.

G. Web Client Workstation

1. Function: This workstation shall be having a Microsoft Pro platform with internet browser and/or client web-app as defined by the HMI software manufacturer. The control screens of the facility I/O server may be accessed via the web-page server, which shares the I/O screens as refreshable web-pages and manages the thin-client access licenses.
2. Web client workstation shall include auto log-out upon session termination and log-in time limit similar to full desktop arrangement

H. Remote Access Server

1. Function: The remote access server allows authorized users to gain access via remote access devices to files and services on the control system network from a remote location.
2. The devices shall have secure access to the facility control system to assist with process control troubleshooting and/or alarm condition assessment. Wired or wireless connection to the public internet will be necessary in order to establish a temporary Virtual Private Network (VPN) connection to the facility via the Owner service provider network.
3. The VPN connection, although temporary, must be and intended to reliable and secure, utilizing IPSec tunneling. Additional login and access restrictions as defined by the OWNER, shall be established such as periodic/regular re-register with the governing domain server (e.g. every 30 days).
4. For security, the number of active remote users shall be coordinated with the OWNER in order to keep them to a minimum.
5. Configuration: As a minimum, the remote access server shall be configured to:
 - a. Offer a separate login challenge point for VPN access.

- b. Contain a registry of all remote devices (MAC address) and users (domain ID)
- c. Only allow use of protocols required to interface with the control system software and suppress use of all other protocols.
- d. Restrict the number of active remote access users.
- e. Invoke full Simple Network Management Protocol (SNMP) services.

2.5 NETWORKING AND DISTRIBUTED OPERATION

- A. The intent of these specifications is for the PLC Based Control System to have a distributed, client/server system architecture to facilitate a distributed type control system. This architecture shall employ a local area network (LAN) as the method for communicating among network and HMI computer nodes. Each node may be assigned one or more tasks.
- B. It is also the intent of these specifications to provide a system, which can be easily expanded and reconfigured. Therefore, all changes in system architecture, expansion of I/Os, modifications to and implementation of control strategies shall be easily done on site mainly through downloading.
- C. Data shall be available to all computers nodes and individuals on the network that have been provided access. Real-time data shall be available directly across the network from the computer that acquired it from the process hardware. Configurations that require each computer to contain copies of database tags it needs to access are not acceptable.
- D. Configuration and Expansion:
 - 1. The CONTRACTOR shall be responsible for configuring the new, and if applicable, the existing network hardware, verifying the firmware, adding communication modules (and other network hardware components as specified) and configuring the network modules to ensure successful working integration with the control system communication network per the contract requirements.
 - 2. The LAN shall comply with the IEEE 802.3 standards for Ethernet and shall operate at a minimum bandwidth of 100Mbps. The network topology shall permit either switched 100BASE-T or 100BASE-TX connections through an auto-negotiating switch.
 - 3. The CONTRACTOR shall provide network node IP addressing and node naming conventions (including field network nodes) for all network switches provided as part of this project.
 - 4. Configurations shall provide selective access to functionality, read/write access to the data and read-only access to all data on the network.
 - 5. The system shall be configured such that the failure of any one computer will not affect the operation of others on the network. It is recognized that data contained in a failed machine will be unavailable to other machines requesting it. However, the system shall offer the provision for re-starting or re-configuring other stations to take over.
 - 6. Redundancy: The CONTRACTOR shall provide a managed, self-healing redundant Ethernet network configuration. The redundant Managed Ethernet Switch shall be

configured per IEEE 802.1d Rapid Spanning Tree Protocol (RSTP) supporting Ethernet TCP/IP communication.

7. The system shall provide an on-line installation and configuration program for configuring the various computers and nodes on the network. This configuration program shall allow assigning unique node names to each computer as well as selecting the functions that the machine will perform.
8. The system will allow additional computers to be added to the network while on-line, without disrupting the operations of the other machines.
9. Client nodes shall have the ability to access multiple servers through the network, one at-a-time or concurrently. Access rights shall be administered from the servers.
10. To minimize network overhead and maximize speed of response, real-time data and any graphics changes shall be passed from server to client on an exception basis. All graphic changes shall be done once at the server level and shall be "broadcasted" globally to all the workstations for the update. The OWNER shall not have to update individual workstations after the changes are made on the server.

E. Local Area Network (LAN) Architecture and Use

1. The system shall be capable of supporting the following network configurations:
 - a. Network Topology
 - 1) Ethernet
 - 2) Token Ring
 - b. Network Protocols
 - 1) TCP/IP
2. The System Supplier shall provide specific details as to the manufacturers and model or version numbers of currently supported topologies and protocols upon request.
3. The system must provide session-oriented communications for data transfer. Each computer station must be capable of establishing up to 100 sessions with other stations.
4. The system must also be capable of running simultaneously with other LAN users who are not operating the data acquisition system software (but who might be using a LAN manager or file transfer software).
5. The application program interface used by all system program modules and by user-written applications shall make MMS-like (Manufacturing Message Specification) Variable Access Service function calls.

F. Error Detection, Diagnostics and Recovery

1. The system shall provide on-line diagnostics that display the current status and operation of the local area network and its nodes. The diagnostic display shall include the LAN adapter status for the machine showing the display, as well as the current number of messages, errors and retries.

2. An additional display shall show the current session status (established, pending, and off-line) of all stations on the network. A session monitor program that automatically monitors and recovers communications shall be supplied with the system.
3. Should network communications errors be detected, the software shall automatically indicate that the data (on graphic displays, in historical files, etc.) is no longer valid and shall replace the invalid data with other characters. The system shall automatically attempt to re-establish communications, and, if successful, shall then replace the characters with valid data. This capability shall be built-in to the software and shall not require any user programming or other user-dependent actions to implement.

G. Network Access

1. On-Line: The system shall have the capability of creating and modifying tags in one node by operating the graphics editor or database builder program in another node. This operation shall be performed on-line, while the destination node is operating. This new or modified tag data shall immediately be available to all other nodes on the network. The security system will restrict access to the database to authorized users.
2. Remote:
 - a. The remote access server shall be integral to a hard firewall appliance or equal network component to ensure maximum segregation and security. Full Simple Network Management Protocol (SNMP) services shall be used (e.g. monitor and record all login attempts (failed and successful) and monitor/record activities of all users remotely logged-in, etc.)
 - b. Configuration shall be available via remote connection. When a remote computer is connected the user shall have the same access as though the user is at a computer directly attached to the network. The following functions shall be supported:
 - 1) Configuring the database tags throughout the network
 - 2) Viewing graphic displays being updated with real-time data
 - 3) Viewing historical trend data
 - 4) Copying files from/to the network

2.6 SOFTWARE TOOLS

A. The system shall be built on and use industry standard development tools.

1. Language: The system must be written predominantly in the C and C++ languages.
2. Data Access
 - a. The system shall provide an open architecture that allows interaction with other programs. It must provide a mechanism for other programs to access individual data elements and fields (such as the high alarm limit of an analog input) within data elements in real time. File transfer mechanisms are not acceptable; the access must be direct to the memory-resident database.

b. The following shall be supported:

- 1) DDE. The system must support Microsoft standard Dynamic Data Exchange (DDE) Server and Client functionality to share data with other DDE-aware applications.
- 2) C/C++. The system shall provide development tools that allow programs written in C or C++ to access (read/write) real-time tag data in the real-time databases on the network.
- 3) Visual BASIC. The system shall provide development tools that allow programs written in Visual BASIC to access (read/write) tag data in the real-time databases on the network.

2.7 CUSTOMER SUPPORT BY SOFTWARE MANUFACTURER

- A. The software manufacture must provide technical support twenty four hours, 7 day a week.

2.8 MANUFACTURERS, OR EQUAL

Invensys Wonderware

GE Intellution iFix

Allen-Bradley RS View

Siemens Clear SCADA

2.9 MISCELLANEOUS UTILITY SOFTWARE

- A. Virus Protection: The Contractor shall furnish virus protection software in each workstation and server that is compatible with HMI software (Symantec, or equal).
- B. File Backup: Software/tools for automatic and manual file back-up (Arcserve, or equal) in each server shall be provided.

PART 3 -- EXECUTION

3.1 INSTALLATION

- A. The PLC programming software shall be provided with the PLC hardware as specified in Section 40 62 02 - PLC-Based Control System Hardware.

3.2 FACTORY TEST

- A. General: The PLC-based control systems-software factory test shall be provided in accordance with Section 40 61 00 - Process Control and Enterprise Management Systems.

3.3 PROGRAMMING, TESTING, AND INSTRUCTION

- A. General: The PLC SCADA System Software, testing, and instruction shall be provided in accordance with Section 40 61 00 - Process Control and Enterprise Management Systems.

3.4 SOFTWARE LICENSE AND REGISTRATION

- A. All software provided shall be installed and used within the terms of the software manufacturer's license agreement. All software purchased by the CONTRACTOR shall be registered to the CONTRACTOR during the construction phase of this project. During that time, the CONTRACTOR shall be responsible for providing and incorporating minor software package updates issued by the software manufacturer. For example, if version 3.1 of a program is purchased, and version 3.2 and 3.3 were released prior to project completion, the CONTRACTOR shall be responsible for incorporating these later versions into the final project. The CONTRACTOR would not be responsible for incorporating major software revisions such as the release of a version 4.0 or 4.1.
- B. Prior to substantial completion of this project, the CONTRACTOR shall re-register all provided software packages to the OWNER and provide the ENGINEER and OWNER with written confirmation of having done so.

3.5 HMI APPLICATION SOFTWARE CONFIGURATION (PROGRAMMING)

A. Graphic Display Configuration

- 1. It is the responsibility of the CONTRACTOR to configure the workstations and to develop, design, engineer, configure and test all of the graphic displays required for this project. All of this work shall take into account the specific needs of the OWNER. The CONTRACTOR shall review the OWNER's existing displays and sketches if available from the OWNER. The CONTRACTOR shall bring to the meeting samples of displays from past projects.
- 2. The CONTRACTOR shall provide up to 20 graphic displays for this project, not including control pop-up windows or trend graphics.
- 3. The CONTRACTOR shall prepare the appropriate submittals and their schedule as specified in Section 40 61 00 - Process Control and Enterprise Management Systems
- 4. In order to facilitate this work the CONTRACTOR shall conduct the following meetings with the OWNER. The CONTRACTOR shall allow 1/2 day for each meeting.
 - a. Graphics Meeting No. 1
 - 1) The CONTRACTOR shall chair and develop an agenda for a meeting which shall address the basic criteria to be adhered to in the configuration and development of the graphic displays. At this meeting, which shall be attended by the OWNER, the CONTRACTOR shall distribute sample display formats for illustration purposes. As a minimum, this meeting shall address the following issues:
 - a) All in- plant and remote site areas and conventions for identifying tag names and descriptors.
 - b) An itemization of the type of display to be used at each level in the graphic hierarchy (e.g., preformatted displays, templates, custom graphics, etc.).
 - c) Organization of the systems universal display hierarchy.

- d) Paging schemes to be used to enable the movement from one display to another.
- e) Definitions of all display select commands that enable the operator to move within the display hierarchy.
- f) Definition of graphic symbolism to be used on the project. This listing shall include but not be limited to symbols to be used for process instrumentation, process equipment, piping, vessels and valves. All symbolism must be specific as opposed to generic in that shapes must define both function and type (e.g., specific symbols for each valve design, each pump design, each type of flow meter, etc.). If the CONTRACTOR's library of shapes does not adequately describe plant or system conditions, the CONTRACTOR shall develop additional shapes to meet the system requirements. Standard displays will include: open/close, modulating valves, on/off, PID, tanks, etc.
- g) Color convention to be employed on all graphics for the annotation of various status information, differentiation between alarms on the basis of alarm priority, background colors, static field colorization, and dynamic field colorization. Color change that indicates change of state of equipment or mode, shall be accompanied by text message. Provide a legend screen(s) in the system to indicate one of each type of equipment symbol and color standard and the meaning of each color. The legend screen shall be accessible from the main menu.
- h) Definition of control input commands which enable the operator to interact with faceplates control stations and custom graphic displays to implement control outputs/functions.
- i) Definition of data input commands which enable the operator to enter/download numeric values into the PLCs.
- j) Definition of control and/or alarm set points display next to its associated analog value or equipment.
- k) Any device that has a selectable mode (e.g. auto-manual, local-remote, etc.) either in the field or at the control center, that mode shall be displayed next to its associated device.
- l) The utilization of cursor movement commands which enable the operator to move within a display.
- m) Definition of the utilization of "poke" points or fields which are dynamically sensitive to operator inputs to facilitate operator entry directly into graphic displays.
- n) The utilization of blinking and conditional text.
- o) Designation of groups within each process area along with tag names and descriptors.
- p) The assignment of individual control loops and inputs to specific groups.

- q) A review of graphic generation procedures.
 - 2) Subsequent to the graphics meeting No. 1 the CONTRACTOR shall prepare and formalize a document titled "GRAPHICS CRITERIA" which shall contain detailed meeting minutes and a definition of all graphic guidelines to be adhered to. This report shall be supplemented by graphic examples which illustrate the incorporation and application of each graphic criterion. The report shall be submitted as indicated in the submittal requirements in Section 40 61 00 - Process Control and Enterprise Management Systems.
- b. Graphics Meeting No. 2
- 1) Subsequent to the finalization of the overall system-wide graphics criteria, the CONTRACTOR shall develop graphic packages for all of the workstations being furnished under this project. At this meeting the CONTRACTOR shall submit the number of copies specified in Section 40 61 00 - Process Control and Enterprise Management Systems - including:
 - a) A review of the graphic package developed for the process areas for content and completeness.
 - b) A review of all data fields that display automatically updated process information.
 - c) A review of all required input commands associated with the graphic access and control manipulation.

B. Graphic Displays Layout and Style:

- 1. The style and the symbols of all the graphic displays shall be uniform. Similar facilities shall have a uniform layout. The graphic display of each facility/site shall be a diagrammatic presentation of the equipment and the piping system of the facility including the suction and discharge piping, with the proper captions.
- 2. As a minimum, the following graphic displays shall be developed for this project (as minimum):
 - a. Plant process overview display, or, If applicable, water distribution and remote sites overview display.
 - b. All processes including all existing interfacing to the PCIS of this project. For remote sites, a station graphic display with a control screen shall be configured. This shall include symbols for pumps, valves, alarm symbols, and operational data.
 - c. PCIS network and nodes
 - d. All group alarm displays.
 - e. All control loop tuning displays.
 - f. All analog faceplate displays with graduation of engineering unit values.
 - g. All custom displays for operator to enter set points and recipe displays.

- h. All key macro icon displays.
- i. All database archiving control displays.
- j. All historical trending display.
- k. Control system network configure and diagnostic.
- l. Communication status and diagnostics display(s)
- m. Redundant communication diagnostic and control.
- n. Redundant master nodes diagnostic and control.
- o. All local nodes diagnostic (include PLC's, Operator Interfacing Units and Instruments).

C. Control, Monitoring and Alarm Configuration

1. For equipment that is controllable from the PLC in either a MANUAL or AUTOMATIC mode, the operator shall be provided with a software "AUTO-MANUAL" selector switch at the operator HMI workstation. Transfer between the MANUAL and AUTOMATIC modes shall be bumpless. This switch is functional only when LOCAL-OFF-REMOTE switch in the field is in REMOTE position. The following are the AUTO- MANUAL functions:
 - a. AUTO – In this position the operator delegates and enables the control of the equipment to be performed at the PLC/control panel. A control mode status signal (AUTO) shall be sent from the workstation to the PLC to indicate when the PLC is allowed to control the equipment.
 - b. MANUAL – In this position the operator bypasses/overrides the control functions in the PLC and manually to controls the equipment from the HMI. In this position, a software switch, such as "START-OFF STOP" or "OPEN-STOP-CLOSE" or manual control of the equipment is enabled as described below.
 - c. A second software switch such as "START-OFF-STOP" or OPEN-STOP-CLOSE", etc. or as required by the application, shall be provided in the HMI to control the equipment in the field manually from the HMI. Variations of these types of control switches shall be provided for the equipment based on its control application. These switches shall be functional only when the above "AUTO-MANUAL" switch is in "MANUAL" mode.
2. The PLC shall monitor the local control mode status switch (LOCAL-OFF-REMOTE) and attempt to control only that equipment which is in the REMOTE mode.
3. Operator Settings: Operator set or entered values shall be constants that are adjustable or set from operator displays. Specific values that are required to be operator set are noted in the process control strategy descriptions.
4. Tunable Values: Tunable values are constants that are adjustable at engineer level displays without requiring any software reconfiguration. These values are not adjustable from operator level displays. Tunable time shall initially set at 10-seconds.

5. All analog and discrete inputs to the PLC shall be displayed. Both RUNNING and OFF input states shall be displayed
 6. Set point, process variable, and controller output shall be displayed.
 7. When equipment is tagged OUT OF SERVICE by the operator, all associated equipment shall have their alarms inhibited until the tagged equipment is re-tagged IN SERVICE.
 8. All PID control functions (P, PI, and PID) shall be provided with standard analog controller functions and operator interfaces including, but not limited to, the following; Provisions shall be included to prevent reset windup.
 - a. AUTO-MANUAL mode selection: In AUTO, the output of controller shall be based on the PID control calculation. In MANUAL, the output of the controller shall be operator adjustable. Transfer between operational modes shall be bumpless.
 - b. LOCAL-OFF-REMOTE set point selection: In LOCAL, the set point shall be operator adjustable from the equipment. In REMOTE, the set point shall be adjustable from a REMOTE set point input.
 9. Motor Protection Relays – All information, including but not limited to: Phase Voltages, Kilowatts, Kilovars, Power Factor, and Frequency shall be monitored and trended.
 10. Power Monitoring - All information, including but not limited to: Phase Voltages, Phase Amps, Kilowatts, Kilovars, Power Factor, and Frequency shall be monitored and trended.
 11. Soft I/O: Software derived I/O points are internal I/O points developed to provide for the necessary functionality typically in the PLC or HMI programming and not from physical equipment or hard wired I/Os. The Soft I/O shall be viewable and/or adjustable from the HMI. The Soft I/O listing is provided for the CONTRACTOR's convenience. The CONTRACTOR shall provide whatever additional required software I/O is to achieve the functional descriptions and the control strategies.
- D. Data Collection: The CONTRACTOR shall provide programming that collects current values of specified variables from on line data storage areas, statistically manipulates data, and creates and maintains an historical data base of collected values. Statistical manipulation shall include linear averaging, filtered averaging, and noting of "bad" values. Statistically manipulated data shall then be stored in a historical database.
1. The frequency of historical collection shall be selectable between once per second to once per month. The type and quantity of historical data shall be selectable by addition and deletion to/from the historical data base.
 2. The CONTRACTOR shall provide adequate online storage to retain 60 days of 6 minute average values for 2,000 variables and hourly maximum, minimum, and average values of 2,000 variables.
 3. The CONTRACTOR shall provide adequate online storage to retain 2 years of daily average values for 2,000 variables and monthly maximum, minimum, and average values for 2,000 variables.

4. Historical records (daily) shall be scheduled to be transferred automatically to a mass storage device.

E. Reports

1. General: The CONTRACTOR shall provide all the reports associated with this project. The reports shall take into account the specific need of the OWNER incorporating any existing reports now being used by the OWNER.
2. In order to facilitate this work the CONTRACTOR shall conduct the two (2) meetings with the OWNER.
3. Report Meeting No.1: The first meeting will be a criteria meeting that shall address the following issues and develop criteria that shall be adhered to in the configuration and development of the reports. Subsequent to the meeting, the CONTRACTOR shall implement the information obtained in the meeting and generate all the required reports and submit a "REPORT CRITERIA". The report shall be similar in nature to the GRAPHICS REPORT. The submittal contents, number of set and submittal schedule shall be in accordance with Section 40 61 00 - Process Control and Enterprise Management Systems. As a minimum, the following criteria shall be developed:
 - a. Review of sample of existing reports that the OWNER may have. The CONTRACTOR shall bring to the meeting samples of display from past projects.
 - b. Organization of the system universal report categories.
 - c. Itemization of the type, titles, and schedule (daily, monthly, yearly) of reports required.
 - d. Definition of terms and engineering units to be used on the reports.
 - e. Definition of report commands that enable the operator to move within the report editor.
 - f. Definition of data input commands that enable the operator to enter numeric values into the system.
 - g. Scheduled and on demand reports.
 - h. Ad hoc reports.
 - i. A review of the report generation procedure.
4. Report Meeting No. 2: Subsequent to the finalization of the report format criteria, the CONTRACTOR shall develop report packages for review. At this meeting the CONTRACTOR shall submit the number of copies specified in Section 40 61 00 - Process Control and Enterprise Management Systems, including:
 - a. A review of the report package developed for the process area(s) for content and completeness.
 - b. A review of all data fields for process information.

- c. A review of all required input commands associated with the report access and control manipulation.
- 5. Process and Production Reporting: The reporting package shall use the process database to provide historical records for an average of 1,000 selected variables. The software as a minimum shall automatically print periodic process and production reports as follows:
 - a. Periodic reports: Process periodic reports shall include:
 - 1) A daily report, which contains hourly information.
 - 2) A weekly report, which contains daily information.
 - 3) A monthly report, which contains daily information.
 - 4) An Annual report, which contains monthly information.
- 6. Maintenance Milestones Reports: For each device for which running information is accumulated, maintenance milestones and reports shall be provided. Whenever the running time and number of starts registers are increments, the milestone registers shall be decremented. As the milestone registers pass zero (indicating maintenance due), decrementing shall continue and display or print out. Decrementing shall continue until the milestone is reset by the operator upon completion of the required maintenance.

F. Trends:

- 1. The CONTRACTOR shall provide time-dependent (24-hours, 7-day, etc.) real time trends for analog variables (e.g. pressure, level, flow, etc.). During the graphic display meetings the OWNER will determine which analog variables will be integrated into a single trend.
- 2. Generally, each trend display shall not have in it more than 4 variables per trend display in it, and each variable shall have its own actual engineering unit vertical scale (no common 0-100% scale) and the x-axis shall be the time scale. The system shall have a trend menu to allow the operator to select trend groups for display as well as real time and historical trends. The operator shall be able save or to print a trend display.
- 3. The real time trend shall display current values. If the historical trends are selected the software shall retrieve the historical data for each variable and display it for the date and the duration selected.

3.6 OPERATIONAL AND FUNCTIONAL PERFORMANCE

- A. Scan Rates: The SCADA system shall be capable of scanning the remote PLCs that communicate over radio within 40-seconds for a complete cycle, based on the following criteria:
 - 1. One analog value change and one digital change of state reported from each PLC.
 - 2. Four (4) PLCs require retransmission of data at the same time.
- B. Data Update Times: Data received from PLCs shall be displayed on the operator consoles (assuming displayed screen contains such data) within one (1) second of

receipt of such data at the central computer, regardless of originating PLC, state of the data received, or the number of stations that require the data. Operator entered command or data change shall be transmitted to the PLC within one (1) second of being entered by the operator.

- C. Screen Displays: Any specified screen display (except trend displays) shall be drawn complete on any furnished monitor, including all real-time data, within three (3) seconds from an operator request for the display.
- D. Trend Displays: Any specified trend display (up to three trend lines and any time interval, both real-time and historical) shall be drawn complete on any monitor within five (5) seconds from an operator request for the trend display.
- E. Reports: Any specified report shall be compiled and printing initiated on any furnished printer within 15 seconds from an operator request for the report.

3.7 TRAINING

- A. The CONTRACTOR shall provide the OWNER with system maintenance and operator training courses on the subjects of use, maintenance, operation, troubleshooting of the components of the PBCS software. The training shall be specifically tailored to this project and reflect the system software installation and configuration. All training shall be conducted on site unless another location is approved by the ENGINEER and OWNER. PBCS software training subjects and the allocated hours for each class shall be in accordance with Section 40 61 00 - Process Control and Enterprise Management Systems.
- B. The CONTRACTOR shall provide by a qualified instructor for all the instrumentation, control, SCADA, communication and computer monitoring and control systems furnished for this project.

END OF SECTION

SECTION 40 71 00 – FLOW MEASUREMENT

PART 1 -- GENERAL

1.01 THE REQUIREMENT

- A. General: The Contractor shall furnish and install all in-line liquid flow measuring systems, complete and operable, in accordance with the Contract Documents.
- B. The requirements of Section 40 61 00 - Process Control and Enterprise Management Systems General Provisions apply to this Section.

1.02 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

A. Reference Specifications

40 61 00	Process Control and Enterprise Management Systems General Provisions
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B. Reference Standards

American National Standards Institute (ANSI)	
ANSI 150	(87th Edition, 1997) Office Machines and Supplies - Business Machines, Data Processing Equipment, and Business Forms - Character and Line Spacing
ANSI Z540.1	(1994; R 2002) Calibration Laboratories and Measuring and Test Equipment - General Requirements
International Organization for Standardization (ISO)	
ISO 10012-1	(1st Edition, 1992) Quality Assurance Requirements for Measuring Equipment - Part 1: Metrological Confirmation System for Measuring Equipment
National Electrical Manufacturers Association (NEMA)	

1.03 CONTRACTOR SUBMITTALS

- A. General: The Contractor shall furnish submittals in accordance with Section 40 61 00 - Process Control and Enterprise Management Systems General Provisions

1.04 QUALITY ASSURANCE

- A. General: The accuracy of each instrumentation system or loop shall conform to the requirements of Section 40 61 00 - Process Control and Enterprise Management Systems General Provisions

1.05 MANUFACTURER'S REPRESENTATIVE SERVICES

- A. General: Manufacturers representative services shall conform to the requirements of Section 40 61 00 - Process Control and Enterprise Management Systems General Provisions.

1.06 PRODUCT HANDLING

- A. General: Product handling shall conform to the requirements of Section 40 61 00- Process Control and Enterprise Management Systems General Provisions.

1.07 GUARANTEE

- A. General: Guarantees shall conform to the requirements of Section 40 61 00 - Process Control and Enterprise Management Systems General Provisions.

PART 2 -- PRODUCTS

2.01 GENERAL

- A. All devices specified herein shall conform to the requirements of the Contract Documents.

2.02 MAGNETIC FLOW MEASURING SYSTEMS

- A. Magnetic Flowmeter (Tube Type):

1. Magnetic flowmeter systems shall be of the low frequency electromagnetic induction type and produce a DC pulsed signal directly proportional to and linear with the liquid flow rate. Complete zero stability shall be an inherent characteristic of the flowmeter system. Each magnetic flow metering system shall include a metering tube, signal cable, and transmitter. The metering tube shall be constructed of 304 stainless steel with flanged connections, have at least 2 diametrically opposed, bullet-nosed, self-cleaning electrodes, a liner material recommended by the manufacturer for the meter's intended service as described in these documents, a meter housing rated for NEMA 6 submergence conditions, and a meter coating consisting of epoxy painted finish.
2. The signal converter/transmitter shall use a DC pulse technique to drive flux-producing coils and convert the DC pulse signal from the tube to a 4-20 mA signal. The signal converter/transmitter shall have a backlit alphanumeric display housed in a NEMA 4X enclosure. It shall have integral zero return to provide a constant zero output signal in response to an external dry contact closure, an integral calibration self-test feature to verify proper operation of the electronics, high and low alarms and an automatic zero adjustment. The transmitter installation shall support integral or remote mounting (up to 300ft). Meter package shall include (2) corrosion resistant grounding rings constructed of the same material as the electrodes.
3. The meter shall be equipped with non-removable electrodes constructed of Hastelloy C. The meter shall support measurement and totalization of bi-directional flow. Installation parameters shall be as follows:
 - a. Minimum 5 pipe diameters of straight pipe upstream
 - b. Minimum 2 pipe diameters of straight pipe downstream
 - c. Horizontal mounting or vertical mounting with upward flow only
 - d. Support for lines sizes from 1-inch to 120-inches

4. Each flow metering system shall be hydraulically calibrated at a facility which is traceable to the US National Bureau of Standards. The calibration procedure shall conform to the requirements of MIL-STD-45662A and/or the more recent ANSI/NCSL Z540-1 or ISO 10012-1 requirements. A real-time computer-generated printout of the actual calibration data indicating apparent and actual flows at 20, 40, 60, 80, and 100 percent of the calibrated range shall be submitted to the Engineer at least 14 days prior to shipment of the meters to the project site.

5. The flow metering system shall conform to the following technical specifications:

Output: 1. (1) 4-20 mA into 600 ohms minimum; Time Constant = 0.5 to 100 seconds; galvanic or optic isolation

2. Scaled pulsed output for totalization

3. HART protocol compatible

Accuracy: $\pm 0.25\%$ of flow rate from 10 to 100% full scale

Repeatability: $\pm 0.05\%$ at ± 0.0008 ft/s

Environmental Limits: - 10 to + 60° C

Power Consumption: 20VA or less

Power Requirements: 110 VAC or 24Vdc, +/- 10%

Accessories: 1. Furnish and install stainless steel sunshield for outdoor/exposed transmitter.

2. Furnish remote mount flow transmitter with a minimum cable length of 50 feet where indicated on contract drawings.

3. Provide stainless steel stanchions for mounting of remote transmitter no less than 4 feet above grade (reference mounting details on Installation Detail sheets).

4. Provide manufacturer digital calibration verification unit with necessary accessories to interface with the furnished magnetic flow meter.

5. Furnish one spool piece for every size magmeter supplied.

Magnetic flow measuring systems shall be as manufactured by:

Siemens Sitrans F M MAG 5100 W

Rosemount 8700 Series

Or Approved Equal

PART 3 -- REFER TO APPENDIX A OF SECTION 40 61 00 - PROCESS CONTROL AND ENTERPRISE MANAGEMENT SYSTEMS GENERAL EXECUTION

3.01 GENERAL

- A. Electrical interface and code compliance shall conform to the requirements of Section 40 61 00 - Process Control and Enterprise Management Systems General Provisions.

3.02 CALIBRATION

- A. The calibration of all devices shall conform to the requirements of Section 40 61 00 - Process Control and Enterprise Management Systems General Provisions.

3.03 INSTALLATION

- A. The installation of all devices shall conform to the requirements of Section 40 61 00 - Process Control and Enterprise Management Systems General Provisions.

3.04 LOOP TESTING

- A. The loop testing of all devices shall conform to the requirements of Section 40 61 00 - Process Control and Enterprise Management Systems General Provisions.

3.05 PRECOMMISSIONING

- A. The pre-commissioning of all devices shall conform to the requirements of Section 40 61 00 - Process Control and Enterprise Management Systems General Provisions.

3.06 ON-SITE SUPERVISION

- A. On-site supervision shall conform to the requirements of Section 40 61 00 - Process Control and Enterprise Management Systems General Provisions.

3.07 PERFORMANCE TESTING

- A. On-site performance tests shall conform to the requirements of Section 40 61 00 - Process Control and Enterprise Management Systems General Provisions.

3.08 RECORD DRAWINGS

- A. Record drawings shall conform to the requirements of Section 40 61 00 - Process Control and Enterprise Management Systems General Provisions.

3.09 TRAINING

- A. Training shall conform to the requirements of Section 40 61 00 - Process Control and Enterprise Management Systems General Provisions.

3.10 ACCEPTANCE

- A. Acceptance shall conform to the requirements of Section 40 61 00 - Process Control and Enterprise Management Systems General Provisions.

END OF SECTION

SECTION 40 72 00 – LEVEL MEASUREMENT

PART 1 -- GENERAL

1.01 THE REQUIREMENT

- A. General: The Contractor shall provide liquid level measuring systems, complete and operable, in accordance with the Contract Documents.
- B. The requirements of Section 40 61 00 - Process Control and Enterprise Management Systems General Provisions apply to this Section.

1.02 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

- A. Reference Specifications

40 61 00	Process Control and Enterprise Management Systems General Provisions
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1.03 CONTRACTOR SUBMITTALS

- A. The Contractor shall furnish submittals in accordance with Section 40 61 00 - Process Control and Enterprise Management Systems General Provisions.

1.04 QUALITY ASSURANCE

- A. General: The accuracy of each instrumentation system or loop shall conform to the requirements of Section 40 61 00 - Process Control and Enterprise Management Systems General Provisions.

1.05 MANUFACTURER'S REPRESENTATIVE SERVICES

- A. General: Manufacturers representative services shall conform to the requirements of Section 40 61 00 - Process Control and Enterprise Management Systems General Provisions.

1.06 PRODUCT HANDLING

- A. General: Product handling shall conform to the requirements of Section 40 61 00 - Process Control and Enterprise Management Systems General Provisions.

1.07 GUARANTEE

- A. General: Guarantees shall conform to the requirements of Section 40 61 00 - Process Control and Enterprise Management Systems General Provisions.

PART 2 -- PRODUCTS

2.01 DIFFERENTIAL PRESSURE TYPE (FLANGED) LEVEL MEASUREMENT

- A. Reference specification section 40 73 00

PART 3 -- EXECUTION

3.01 GENERAL

- A. Electrical interface and code compliance shall conform to the requirements of Section 40 61 00 - Process Control and Enterprise Management Systems General Provisions.

3.02 CALIBRATION

- A. The calibration of all devices shall conform to the requirements of Section 40 61 00 - Process Control and Enterprise Management Systems General Provisions.

3.03 INSTALLATION

- A. The installation of all devices shall conform to the requirements of Section 40 61 00 - Process Control and Enterprise Management Systems General Provisions.

3.04 LOOP TESTING

- A. The loop testing of all devices shall conform to the requirements of Section 40 61 00 - Process Control and Enterprise Management Systems General Provisions.

3.05 PRECOMMISSIONING

- A. The precommissioning of all devices shall conform to the requirements of Section 40 61 00 - Process Control and Enterprise Management Systems General Provisions.

3.06 ON-SITE SUPERVISION

- A. The on-site supervision of all devices shall conform to the requirements of Section 40 61 00 - Process Control and Enterprise Management Systems General Provisions.

3.07 PERFORMANCE TESTING

- A. The performance testing of all devices shall conform to the requirements of Section 40 61 00 - Process Control and Enterprise Management Systems General Provisions.

3.08 RECORD DRAWINGS

- A. Record Drawings shall conform to the requirements of Section 40 61 00 - Process Control and Enterprise Management Systems General Provisions.

3.09 TRAINING

- A. Training for all equipment and software shall conform to the requirements of Section 40 61 00 - Process Control and Enterprise Management Systems General Provisions.

3.10 ACCEPTANCE

- A. All acceptance testing shall conform to the requirements of Section 40 61 00 - Process Control and Enterprise Management Systems General Provisions.

END OF SECTION

SECTION 40 72 76 – LEVEL SWITCHES

PART 1 -- GENERAL

1.01 THE REQUIREMENT

- A. General: The Contractor shall provide level detection switches, complete and operable, in accordance with the Contract Documents.
- B. The requirements of Section 40 61 00 - Process Control and Enterprise Management Systems General Provisions apply to this Section.

1.02 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

- A. Reference Specifications

40 61 00	Process Control and Enterprise Management Systems General Provisions
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1.03 CONTRACTOR SUBMITTALS

- A. The Contractor shall furnish submittals in accordance with Section 40 61 00 - Process Control and Enterprise Management Systems General Provisions.

1.04 QUALITY ASSURANCE

- A. General: The accuracy of each instrumentation system or loop shall conform to the requirements of Section 40 61 00 - Process Control and Enterprise Management Systems General Provisions.

1.05 MANUFACTURER'S REPRESENTATIVE SERVICES

- A. General: Manufacturers representative services shall conform to the requirements of Section 40 61 00 - Process Control and Enterprise Management Systems General Provisions.

1.06 PRODUCT HANDLING

- A. General: Product handling shall conform to the requirements of Section 40 61 00 - Process Control and Enterprise Management Systems General Provisions.

1.07 GUARANTEE

- A. General: Guarantees shall conform to the requirements of Section 40 61 00 - Process Control and Enterprise Management Systems General Provisions.

PART 2 -- PRODUCTS

2.01 FLOAT TYPE LIQUID LEVEL SWITCHES

- A. Liquid level (mercury-free) switches shall be the side mounted float actuated type. Float switches shall be SPDT and shall consist of a fixed sealed reed switch actuated by a floating magnet. Level switches shall be flange or plug mounted to suit field requirements. Process wetted materials shall be Teflon.

- B. Liquid level switches shall be as manufactured by **MAGNETROL “TUFFY”** or Engineer approved equal. Refer to Appendix A of Section 40 61 00 - Process Control and Enterprise Management Systems General Provisions for the complete instrument schedule.

PART 3 -- EXECUTION

3.01 GENERAL

- A. Electrical interface and code compliance shall conform to the requirements of Section 40 61 00 - Process Control and Enterprise Management Systems General Provisions.

3.02 CALIBRATION

- A. The calibration of all devices shall conform to the requirements of Section 40 61 00 - Process Control and Enterprise Management Systems General Provisions.

3.03 INSTALLATION

- A. The installation of all devices shall conform to the requirements of Section 40 61 00 - Process Control and Enterprise Management Systems General Provisions.

3.04 LOOP TESTING

- A. The loop testing of all devices shall conform to the requirements of Section 40 61 00 - Process Control and Enterprise Management Systems General Provisions.

3.05 PRECOMMISSIONING

- A. The pre-commissioning of all devices shall conform to the requirements of Section 40 61 00 - Process Control and Enterprise Management Systems General Provisions.

3.06 ON-SITE SUPERVISION

- A. The on-site supervision of all devices shall conform to the requirements of Section 40 61 00 - Process Control and Enterprise Management Systems General Provisions.

3.07 PERFORMANCE TESTING

- A. The performance testing of all devices shall conform to the requirements of Section 40 61 00 - Process Control and Enterprise Management Systems General Provisions.

3.08 RECORD DRAWINGS

- A. Record Drawings shall conform to the requirements of Section 40 61 00 - Process Control and Enterprise Management Systems General Provisions.

3.09 TRAINING

- A. Training for all equipment and software shall conform to the requirements of Section 40 61 00 - Process Control and Enterprise Management Systems General Provisions.

3.10 ACCEPTANCE

- A. All acceptance testing shall conform to the requirements of Section 40 61 00 - Process Control and Enterprise Management Systems General Provisions.

END OF SECTION

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SECTION 40 73 00 – PRESSURE, STRAIN, AND FORCE MEASUREMENT

PART 1 -- GENERAL

1.01 THE REQUIREMENT

- A. **General:** The Contractor shall furnish and install all pressure measuring systems, complete and operable, in accordance with the Contract Documents.
- B. The requirements of Section 40 61 00 – Process Control and Enterprise Management Systems General Provisions apply to this Section.

1.02 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

- A. Reference Specifications

40 61 00	Process Control and Enterprise Management Systems General Provisions
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1.03 CONTRACTOR SUBMITTALS

- A. **General:** In addition to the Shop Drawing requirements of Section 40 61 00 – Process Control and Enterprise Management Systems General Provisions, the Contractor shall furnish submittals in accordance with Section 40 61 00 – Process Control and Enterprise Management Systems General Provisions. QUALITY ASSURANCE
- B. **General:** The accuracy of each instrumentation system or loop shall conform to the requirements of Section 40 61 00 – Process Control and Enterprise Management Systems General Provisions.

1.04 MANUFACTURER'S REPRESENTATIVE SERVICES

- A. **General:** Manufacturers representative services shall conform to the requirements of Section 40 61 00 – Process Control and Enterprise Management Systems General Provisions.

1.05 PRODUCT HANDLING

- A. **General:** Product handling shall conform to the requirements of Section 40 61 00 – Process Control and Enterprise Management Systems General Provisions.

1.06 GUARANTEE

- A. **General:** Guarantees shall conform to the requirements of Section 40 61 00 – Process Control and Enterprise Management Systems General Provisions.

PART 2 -- PRODUCTS

2.01 PRESSURE GAUGES

- A. Pressure gauges shall be 4-1/2 inches in diameter, liquid-filled, bottom connected, with white laminated dials and black graduations. Windows shall be shatterproof glass. Gauges shall have a blowout disc and be encased in phenolic, steel or cast iron. Measuring element shall be a stainless-steel bourdon tube with welded, stress-relieved joints. Socket shall have wrench flats. Movement shall be rotary geared, all stainless-steel material. All pressure gauges shall be provided with a pulsation snubber constructed of 316 stainless steel and a ball isolation valve. Accuracy shall be plus or minus 0.5 percent range to 150 percent of the working pressure or vacuum of the pipe or vessel to which they are connected.
- B. Pressure gauges shall be as manufactured by:
 - 1. **Ashcroft 1279**
 - 2. **Ametek Solfrunt Series 1900**
 - 3. **Or approved equal.**
- C. Unless noted otherwise, all pressure gauges represented on the P&ID contract drawings are to be provided by the Contractor. Refer to Appendix A of Section 40 61 00 – Process Control and Enterprise Management Systems General Provisions for the complete instrument schedule.

2.02 ELECTRONIC DIFFERENTIAL PRESSURE TRANSMITTERS

- A. **Components:** Electronic differential transmitters shall be of the differential pressure type and consist of a capsule assembly, bottom works, weather-proof and bug-proof atmospheric vent plug assembly, drain plug, cover flange, process connector and connection, teflon gaskets, amplifier unit, integral indicator, terminal box with cover, block and bleed valves, and conduit connections. Electronic differential transmitters shall be housed in a NEMA 4X enclosure. Flow Indicating Transmitters (FIT) shall be provided with three valve stainless steel manifolds. Level Indicating Transmitters (LIT) and Pressure Indicating Transmitters (PIT) shall be provided with two valve stainless steel manifolds.
- B. **Operating Principles:** Pressure applied to the transmitter shall be transmitted by a sealed fill fluid to both sides of a sensing diaphragm. The sensing diaphragm and the sensor body shall function respectively as the moving and fixed electrodes of a differential capacitor. As the applied pressure causes the diaphragm to move, the capacitance of the cell shall change.
- C. **Performance Requirements**
 - 1. The transmitter enclosure (top-works) shall be rotatable to facilitate access to the electronics with an over-rotation stop to prevent damage to sensor wires.
 - 2. The amplifier unit shall convert the change in capacitance to a 4-20mA DC signal, 2-wire type, with an allowable loop load of no less than 575 ohms.
 - 3. Transmitter design shall incorporate voltage surge and RFI protection.

4. Static pressure rating shall be a minimum of 500 psig. The maximum overrange pressure limit shall be a minimum of 150 percent of the maximum range.
 5. Span shall be adjustable over a minimum of a 7:1 range. External adjustments shall include zero and span.
 6. Output signal damping shall be provided as an internal adjustment. Square root extraction circuitry, as will be required for venturi flow measurement applications, shall be provided as an option which can be added or removed from the transmitter.
 7. All equipment shall be suitable for an ambient operating range of minus 40 degrees F to plus 212 degrees F.
 8. All block and bleed valves shall be constructed of 316 stainless steel. Bolts for process covers and process connectors shall be of the same material as that specified for the process covers.
 9. The top-works shall be constructed of low copper die-cast aluminum and finished with epoxy paint.
 10. The integral indicator shall have a linear scale and be calibrated in process units. Power supply shall be 24 VDC.
 11. Accuracy, including linearity and repeatability, shall be a plus or minus 0.2 percent of span. Hysteresis shall be limited to 0.05 percent of span. Drift, over a six-month period shall not exceed 0.1 percent of reference span. Ambient temperature effect shall be limited to no more than plus or minus 0.5 percent of maximum span per 100° F.
 12. Transmitter is to utilize "Smart" technology which employs a hand-held configuration terminal and complies with HART protocol.
- D. **Materials:** All wetted parts including block and bleed valves parts shall be constructed of 316 stainless steel.
- E. Manufacturers (differential pressure):
1. **Rosemount Model 3051CD or 3051L**
 2. **Endress & Hauser Deltabar S PMD/FMD-75 series**
 3. **Or equal.**
- F. Manufactures (absolute pressure / gauge pressure):
1. **Endress & Hauser Cerebar S PMP71 or PMP75**
 2. **Rosemount 3051CG or 3051TG**
 3. **Or equal.**

PART 3 -- EXECUTION

3.01 GENERAL

- A. Electrical interface and code compliance shall conform to the requirements of Section 40 61 00 – Process Control and Enterprise Management Systems General Provisions.

3.02 CALIBRATION

- A. The calibration of all devices shall conform to the requirements of Section 40 61 00 – Process Control and Enterprise Management Systems General Provisions.

3.03 INSTALLATION

- A. The installation of all devices shall conform to the requirements of Section 40 61 00 – Process Control and Enterprise Management Systems General Provisions.

3.04 LOOP TESTING

- A. The loop testing of all devices shall conform to the requirements of Section 40 61 00 – Process Control and Enterprise Management Systems General Provisions.

3.05 PRECOMMISSIONING

- A. The pre-commissioning of all devices shall conform to the requirements of Section 40 61 00 – Process Control and Enterprise Management Systems General Provisions.

3.06 *ON-SITE SUPERVISION*

- A. The on-site supervision of all devices shall conform to the requirements of Section 40 61 00 – Process Control and Enterprise Management Systems General Provisions.

3.07 PERFORMANCE TESTING

- A. The performance testing of all devices shall conform to the requirements of Section 40 61 00 – Process Control and Enterprise Management Systems General Provisions.

3.08 RECORD DRAWINGS

- A. Record Drawings shall conform to the requirements of Section 40 61 00 – Process Control and Enterprise Management Systems General Provisions.

3.09 TRAINING

- A. Training for all equipment and software shall conform to the requirements of Section 40 61 00 – Process Control and Enterprise Management Systems General Provisions.

3.10 ACCEPTANCE

- A. All acceptance testing shall conform to the requirements of Section 40 61 00 – Process Control and Enterprise Management Systems General Provisions.

END OF SECTION

SECTION 40 75 00 – PROCESS LIQUID ANALYTICAL MEASUREMENT

PART 1 -- GENERAL

1.01 THE REQUIREMENT

- A. **General:** The Contractor shall furnish and install all process analyzer measuring systems, complete and operable, in accordance with the Contract Documents.
- B. The requirements of Section 40 61 00 – Process Control and Instrumentation Systems apply to this Section.

1.02 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

- A. Reference Specifications

40 61 00	Process Control and Enterprise Management Systems General Provisions
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1.03 CONTRACTOR SUBMITTALS

- A. **General:** The Contractor shall furnish submittals in accordance with Section 40 61 00 – Process Control and Instrumentation Systems.

1.04 QUALITY ASSURANCE

- A. **General:** The accuracy of each instrumentation system or loop shall conform to the requirements of Section 40 61 00 – Process Control and Instrumentation Systems.

1.05 MANUFACTURER'S REPRESENTATIVE SERVICES

- A. **General:** Manufacturers representative services shall conform to the requirements of Section 40 61 00 – Process Control and Instrumentation Systems.

1.06 PRODUCT HANDLING

- A. **General:** Product handling shall conform to the requirements of Section 40 61 00 – Process Control and Instrumentation Systems.

1.07 GUARANTEE

- A. **General:** Guarantees shall conform to the requirements of Section 40 61 00 – Process Control and Instrumentation Systems.

PART 2 -- PRODUCTS

2.01 GENERAL

- A. **Signal Output:** Analyzers shall be “smart” type and shall support remote configuration and calibration. Analyzers shall be interfaced to the plant control system using current regulated 4-20 mA HART protocol (driving 0 to 600 ohms). The Contractor shall perform a complete configuration check of each transmitter prior to site installation.

- B. **Power Input:** Analog signal analyzers shall be fully isolated 2-wire type (i.e., loop-powered) wherever possible. However, if separate power is required for a given device, 24VDC (delivered from the signal handling cabinet) will be the preferred installation approach. If neither type is available for a given application, the analyzer shall be fully isolated 4-wire type with power supply of 120 volts plus and minus 10 percent, 60 Hz plus and minus 5 percent.
- C. **Ambient Conditions:** Analyzers shall be suitable for continuous automatic on-line analysis of the indicated parameter under the conditions indicated.
 - 1. Equipment shall operate satisfactorily in ambient temperatures between 0 degrees and plus 132 degrees F or shall be provided with isothermal enclosures so that accuracies will not exceed one percent of span.
 - 2. Process fluid temperatures will range between 32- and 120-degrees F unless indicated otherwise.
- D. **Sample Flow:** Flow to non- inline analyzers (generally wet panel-mounted) shall be monitored by a thermal flow switch. Detected loss of flow shall result in generation of control system process alarm. Samples shall not pass-through housings containing electronics unless specifically indicated otherwise.
- E. **Local Indication:** Each analyzer shall be provided with local indicator scaled to match the indicated process units (refer to Section 40 61 00 – Process Control and Instrumentation Systems Appendix A – Instrument List).
- F. **Calibration:** HART transmitters shall be scaled and configured using the appropriate smart calibration device. Standard 4-20mA analyzers shall be fitted with calibration connections at the analyzer as required by the manufacturer.
- G. **Single manufacturer:** All electrodes, fittings, and transmitters on analyzers measuring the same parameter shall be products of a single manufacturer.

2.02 AMPEROMETRIC FREE AND TOTAL CHLORINE RESIDUAL MEASURING SYSTEMS

- A. **Transmitter:** The total residual chlorine analyzer shall be microprocessor based, capable of the accurate determination of residual chlorine in the range of 0-10 ppm with an accuracy of 0.5% of measuring range and repeatability of +/-2% of reading at constant temperature. Results (chlorine residual and the correction variable: pH or temperature, as applicable), settings and alarms shall be displayed on a high resolution, backlit LCD display. The analyzer shall be capable of automatic pH correction over the range of 6.5 to 9.5 pH without the use of reagents and shall be capable of accommodating a separate pH sensor to facilitate correction of significant variation on pH. The analyzer shall also be capable of automatic temperature correction over the range of 5° – 45°C. (Temperature may be displayed in °C or °F.) Continuous self-diagnostics for operational errors or equipment problems shall be standard. Dual alarms with programmable logic shall be standard along with a third relay with timer functions. A programmable direct or reverse acting isolated 4-20 mA output for chlorine concentration, expandable over the analyzer's range of measurement shall be standard with second 4-20 mA output for pH readings also furnished. All functions including zero and calibration, alarm and 4-20 mA outputs, variable input filter and output dampening, and keypad security shall be accessible from the front panel silicon keypad. Transmitter shall be two-wire type (nominal 24 Vdc) and shall be housed within a PPE Nema 4X (IP65) enclosure suitable for wall, handrail or panel mounting.

B. The analyzer smart transmitter shall be as manufactured by:

1. **HACH, SC4500 Digital Controller**

C. **Chlorine Sensor:** The residual chlorine sensor shall be of the passive amperometric type with a gold cathode, silver anode isolated from the sample by a chloramine permeable membrane and an electrolyte reservoir of 30 ml. The sensor shall include automatic pressure compensation to prevent any pressure influence when tested to 65 psig. The sensor shall also have a 100-ohm RTD for automatic temperature compensation over the range of 0-50°C. Each sensor shall have a replaceable membrane assembly, so constructed that replacement membranes will cause less than a 3% change in readings and be supplied with a minimum of 3 replacement membranes and 4 oz. of electrolyte. The sensor shall have a minimum service period of 4 to 6 months between electrolyte changes. The consumable materials in the sensor shall be sufficient for a minimum of 3 years of sensor life at ambient operating conditions. Sensors shall be designed to be replaced without removal of the sensor cable.

D. The total chlorine residual sensor shall be as manufactured by:

1. **HACH, CLT10sc (Chlorine Panel)**

2. **Engineer approved equal.**

E. Sensors shall include 1 m cable and all components and assemblies necessary for flow-through analysis installation. Sensors shall be furnished complete with a one-year supply of spare membrane assemblies and sensor electrolyte (as applicable). Transmitter and sensor shall be of the same manufacturer. Refer to Section [[[40 61 00]]] [[[13420]]] – Process Control and Instrumentation Systems Appendices for the complete instrument schedule.

PART 3 -- EXECUTION

3.01 GENERAL

A. Electrical interface and code compliance shall conform to the requirements of Section 40 61 00 – Process Control and Instrumentation Systems.

3.02 CALIBRATION

A. The calibration of all devices shall conform to the requirements of Section 40 61 00 – Process Control and Instrumentation Systems.

3.03 INSTALLATION

A. The installation of all devices shall conform to the requirements of Section 40 61 00 – Process Control and Instrumentation Systems.

3.04 LOOP TESTING

A. The loop testing of all devices shall conform to the requirements of Section 40 61 00 – Process Control and Instrumentation Systems.

3.05 PRE-COMMISSIONING

- A. The pre-commissioning of all devices shall conform to the requirements of Section 40 61 00 – Process Control and Instrumentation Systems.

3.06 ON-SITE SUPERVISION

- A. The on-site supervision of all devices shall conform to the requirements of Section 40 61 00 – Process Control and Instrumentation Systems.

3.07 PERFORMANCE TESTING

- A. The performance testing of all devices shall conform to the requirements of Section 40 61 00 – Process Control and Instrumentation Systems.

3.08 RECORD DRAWINGS

- A. Record Drawings shall conform to the requirements of Section 40 61 00 – Process Control and Instrumentation Systems.

3.09 TRAINING

- A. Training for all equipment and software shall conform to the requirements of Section 40 61 00 – Process Control and Instrumentation Systems.

3.10 ACCEPTANCE

- A. All acceptance testing shall conform to the requirements of Section 40 61 00 – Process Control and Instrumentation Systems.

END OF SECTION

SECTION 40 76 36 – PRESSURE AND DIFFERENTIAL PRESSURE SWITCHES

PART 1 -- GENERAL

1.01 THE REQUIREMENT

- A. **General:** The Contractor shall furnish and install all pressure detection systems, complete and operable, in accordance with the Contract Documents.
- B. The requirements of Section 40 61 00 – Process Control and Enterprise Management Systems General Provisions apply to this Section.

1.02 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

- A. Reference Specifications

40 61 00	Process Control and Enterprise Management Systems General Provisions
40 73 00	Pressure, Strain, and Force Measurement

1.03 CONTRACTOR SUBMITTALS

- A. **General:** The Contractor shall furnish submittals in accordance with Section 40 61 00 – Process Control and Enterprise Management Systems General Provisions.

1.04 QUALITY ASSURANCE

- A. **General:** The accuracy of each instrumentation system or loop shall conform to the requirements of Section 40 61 00 – Process Control and Enterprise Management Systems General Provisions.

1.05 MANUFACTURER'S REPRESENTATIVE SERVICES

- A. **General:** Manufacturers representative services shall conform to the requirements of 40 61 00 – Process Control and Enterprise Management Systems General Provisions.

1.06 PRODUCT HANDLING

- A. **General:** Product handling shall conform to the requirements of Section 40 61 00 – Process Control and Enterprise Management Systems General Provisions.

1.07 GUARANTEE

- A. A. **General:** Guarantees shall conform to the requirements of Section 40 61 00 – Process Control and Enterprise Management Systems General Provisions.

PART 2 -- PRODUCTS

2.01 ADJUSTABLE PRESSURE SWITCH

- A. Unit shall be operated by a diaphragm and plunger actuating a snap switch (mercury switches shall not be accepted). Pressure switch shall have dual adjustments with two SPDT contacts rated for a minimum of 5 Amps at 120VAC. The dead band shall be adjustable up to 100 percent of full scale. Set points shall fall between 20 and 80 percent of the adjustable range. The diaphragm shall be Buna-N, unless otherwise indicated, and the lower housing shall be 316 stainless steel with a ¼-inch bottom sensing connection, unless otherwise indicated.
- B. Adjustable pressure switches shall be as manufactured by Ashcroft, Series PPxN7 for Nema 7/9 applications and Series GPxN4 for Nema 4X applications or Engineer approved equal.
- C. Refer to Appendix A of Section 40 61 00 – Process Control and Enterprise Management Systems General Provisions for the complete instrument schedule.

PART 3 -- EXECUTION

3.01 GENERAL

- A. Electrical interface and code compliance shall conform to the requirements of Section 40 61 00 – Process Control and Enterprise Management Systems General Provisions.

3.02 CALIBRATION

- A. The calibration of all devices shall conform to the requirements of Section 40 61 00 – Process Control and Enterprise Management Systems General Provisions.

3.03 INSTALLATION

- A. The installation of all devices shall conform to the requirements of Section 40 61 00 – Process Control and Enterprise Management Systems General Provisions.

3.04 LOOP TESTING

- A. The loop testing of all devices shall conform to the requirements of Section 40 61 00 – Process Control and Enterprise Management Systems General Provisions.

3.05 PRECOMMISSIONING

- A. The pre-commissioning of all devices shall conform to the requirements of Section 40 61 00 – Process Control and Enterprise Management Systems General Provisions.

3.06 ON-SITE SUPERVISION

- A. The on-site supervision of all devices shall conform to the requirements of Section 40 61 00 – Process Control and Enterprise Management Systems General Provisions.

3.07 PERFORMANCE TESTING

- A. The performance testing of all devices shall conform to the requirements of Section 40 61 00 – Process Control and Enterprise Management Systems General Provisions.

3.08 RECORD DRAWINGS

- A. Record Drawings shall conform to the requirements of Section 40 61 00 – Process Control and Enterprise Management Systems General Provisions.

3.09 TRAINING

- A. Training for all equipment and software shall conform to the requirements of Section 40 61 00 – Process Control and Enterprise Management Systems General Provisions.

3.10 ACCEPTANCE

- A. All acceptance testing shall conform to the requirements of Section 40 61 00 – Process Control and Enterprise Management Systems General Provisions.

END OF SECTION

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SECTION 43 11 00 – BLOWERS AND COMPPRESSORS

PART 1 -- GENERAL

1.01 THE SUMMARY

- A. The Contractor shall provide air compressor and appurtenances, complete and operable, in accordance with the Contract Documents.
- B. Air compressor shall provide maintenance support for bladder-type surge tank and general maintenance support. Air compressor hoses and connection pieces shall be compatible with surge tank connections and city-owned air tools.
- C. The requirements of Section 46 01 00 - Equipment General Provisions apply to the Work of this Section.
- D. The Contractor shall assign to a single manufacturer full responsibility for the furnishing and functional operation of the blower, compressor, or vacuum pump unit, including drives, drive motors, speed control equipment (where variable speed drives are required), and accessories. The designated single manufacturer, however, need not manufacture more than one part of the unit (blower, or motor and drive), but shall coordinate the design, assembly, testing, and erection of the unit.

1.02 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

A. Reference Specifications

01 33 00	Submittal Procedures
01 33 17	Structural Design, Support and Anchorage
26 05 10	Electric Motors
40 61 96	Process Control Descriptions
40 73 00	Pressure, Strain, and Force Measurement
46 01 00	Equipment General Provisions

B. Reference Standards

American National Standards Institute (ANSI)	
ANSI B16.1	Cast Iron Pipe Flanges and Flanged Fittings, Class 25, 125, 250, and 800
ANSI B16.5	Pipe Flanges and Flanged Fittings, Steel Nickel Alloy and Other Special Alloys
American Society of Mechanical Engineers (ASME)	
ASME PTC 9	Performance Test Code - Displacement Compressors, Vacuum Pumps and Blowers
ASME PTC 10	Performance Test Code - Compressors and Exhausters
ASME B31.1	Power Piping
ASTM International (ASTM)	
ASTM A 48	Gray Iron Castings
Institute of Electrical and Electronics Engineers (IEEE)	

1.03 CONTRACTOR SUBMITTALS

- A. Furnish submittals in accordance with Section 01 33 00 – Submittal Procedures.
- B. Shop Drawings: Shop Drawings shall contain the following information:
 - 1. Equipment name, identification number, and specification number.
 - 2. Performance curve and data.
 - 3. The Contractor shall require the manufacturer to indicate points on the H/Q curves, and the limits recommended for stable operation between which the blowers may be operated without surge and vibration. The stable operating range shall be as wide as possible based on actual tests, performed at the factory in accordance with the ASME PTC 9 and 10 test codes.
 - 4. Equipment detailed description and specification.
 - 5. Electrical data including control and wiring diagrams.
 - 6. Assembly and installation drawings including shaft size, seal, coupling, anchor bolt plan, part nomenclature, material list, outline dimensions, and shipping weights.
 - 7. Equipment drives and motor in accordance with Section 26 05 10 – Electric Motors.
- C. Certification: The Contractor shall obtain written certification from the designated single manufacturer, addressed to the Owner, stating that the equipment will efficiently and thoroughly perform the required functions and that the designated single manufacturer accepts the Contractor's assignment of full responsibility for coordination of all equipment, including motors, variable speed drives, controls, and services required for proper installation and operation of the completely assembled and installed unit(s). The Contractor shall submit such certificates to the Engineer.
- D. O & M Manuals: Prior to start-up, furnish complete operations and maintenance manuals in accordance with Section 01 33 00 –Submittal Procedures. Printed instructions relating to proper maintenance, including lubrication, and parts lists indicating the various parts by name, number, and diagram where necessary, shall be furnished in duplicate with each unit or set of identical units in each station. A recommended spare parts list shall be included. Instructions for field procedures for erection, adjustments, inspection, and testing shall be provided prior to installation of each piece of equipment.

1.04 QUALITY ASSURANCE

- A. Equipment Testing: The Contractor shall be responsible for the coordination of the following tests of each blower, compressor, and vacuum pump, drive, and motor:

1. General: Tests shall be performed in accordance with the ASME PTC 9 and 10 Performance Test Codes. Tests shall be performed on the actual assembled unit from surge condition to 25 percent above the required design capacity. Prototype model tests will not be acceptable. Equipment shall be factory witness-tested, as defined herein.
 2. Factory Tests of Blowers and Compressors: Blowers, compressors, and motors of sizes 10 to 125 hp (inclusive) shall be factory-tested in accordance with the above requirements. Seven sets of certified test data shall be submitted to the Engineer.
 3. Factory Tests of Motors: Motors of size 10 hp and larger shall be assembled, tested, and certified at the factory and the working clearances checked to ensure that parts are properly fitted. The tests shall be in accordance with IEEE 112 standards, including heat run and efficiency tests. Computations shall be recorded and 7 certified and dated copies of the test results shall be furnished to the Engineer.
 4. Factory Witnessed Tests: Blowers and compressors, variable speed drives, and motors 150 hp and larger, shall be factory-tested as complete, assembled units, as indicated above, and witnessed by the Engineer. The Contractor shall give the Engineer a minimum of 2 weeks notification prior to the test. Costs for Owner and Engineer representative expenses shall be borne by the Contractor and included in the Bid price. Such costs shall include travel and subsistence for 2 persons but shall exclude salaries. Test results in triplicate shall be submitted to the Engineer and no equipment shall be shipped until the test data have been approved by the Engineer.
 5. Acceptance: In the event of failure of any blower or compressor to meet any of the above requirements or efficiencies, the Contractor shall make necessary modifications, repairs, or replacements to conform to the requirements of the Contract Documents and the equipment shall be re-tested at no additional compensation until found satisfactory.
- B. Field Tests: Units shall be field tested after installation, in accordance with the Contract Documents, to demonstrate satisfactory operation, without causing excessive noise, vibration, and overheating of the bearings. The field testing shall be performed by the Contractor in the presence of a factory-trained, experienced field representative of the manufacturer, who shall supervise the following tasks and shall certify in writing that the equipment and controls have been properly installed, aligned, lubricated, adjusted, and readied for operation:
1. Start-up, check, and operate the equipment over the entire speed range. The vibration shall be within acceptable limits.
 2. Equipment performance shall be documented by obtaining concurrent readings, showing motor voltage, amperage, and discharge head. Each power lead to the motor shall be checked for proper current balance.
 3. Bearing temperatures shall be determined by a contact-type thermometer. A running time of at least 20 minutes shall be maintained for this test.
 4. Electrical and instrumentation testing shall conform to other applicable Sections of the Specifications.

5. The field testing will be witnessed by the Engineer. In the event any of the equipment fails to meet the above test requirements, it shall be modified and retested in accordance with the requirements of this Section. The Contractor shall then certify in writing that the equipment has been satisfactorily tested, and that final adjustments thereto have been made. Certification shall include date of final acceptance test, as well as a listing of persons present during tests, and resulting test data. The costs of work by factory-trained representatives shall be borne by the Contractor. The Owner will pay for power costs. When available, the Owner's operating personnel will provide assistance in the field testing.

1.05 MANUFACTURER'S SERVICE REPRESENTATIVE

- A. Erection and Startup Assistance: Service and instruction assistance by the manufacturer's service representative for each blower and compressor unit 10 hp and larger shall be provided by the Contractor during the following periods:
1. One day (minimum) during installation.
 2. One day (minimum) during startup.
- B. Instruction of Owner's Personnel: The Contractor shall provide for the services of a factory service representative to instruct the Owner's personnel in the operation and maintenance of the equipment.

1.06 GUARANTEES, WARRANTIES

- A. After completion, the Contractor shall furnish to the Owner the manufacturer's written guarantees, that the equipment will operate with the published efficiencies, heads, and flow ranges and meet these specifications. The Contractor shall also furnish the manufacturer's warranties as published in its literature.

PART 2 -- PRODUCTS

2.01 GENERAL

- A. Identification: Air Compressor

Equipment number	COM-200
Quantity	1
Location	Booster Pump Station - Pump Room

- B. Operating Conditions: The WORK of this Section shall be suitable for long term operation under the following conditions:

Duty	Intermittent
Drive	Constant Speed
Ambient temperature, degrees F	45 to 85
Ambient relative humidity, percent	30 to 100

Fluid service	Air
Air Compressor Resting elevation	888.3
Power supply	480-volt 3-phase 60 Hz

C. Compressor Performance Requirements

Compressor Hydraulic Requirements	Description
Maximum pressure, psig	250
Design pressure, psig	175
Design flow capacity, cfm	24
Belt type	A
Belt Quantity	1
Minimum/Maximum speed, rpm	575/1600
Motor Horsepower, HP	7.5
Brake Horsepower, HP	8.1

D. Tank Requirements

Compressor Tank Requirements	Description
Orientation	Vertical
Size, gal	80
Pressure rating, psig	200
Code Requirements	ASME Section 8 and CRN

E. Compressor Dimensions

Description Dimensions	Pump Dimensions
Inlet connection type	NTP

Inlet size, inches	1"
Discharge connection type	NTP
Discharge size, inches	0.5"
Connection ratings, psi	200

- F. Wherever it is required that a single designated manufacturer shall be responsible for the compatible and successful operation of the various components of any equipment, it shall be understood to mean that the Contractor shall provide only such equipment as the manufacturer will certify is compatible with its equipment and with the further understanding that this in no way constitutes a waiver of any requirements.
- G. Manufactured items provided under this Section shall be new, current models, and the products of reputable companies specializing in the manufacture of such products, with previous experience in such manufacture. The Contractor shall, upon request of the Engineer, furnish the names of not less than 5 successful installations of its equipment of comparable nature to that offered under this Contract.

2.02 MATERIALS

- A. Materials employed in the blower and compressor equipment shall be suitable for the intended application; material not indicated shall be high-grade, standard commercial quality, free from any defects and imperfections that might affect the serviceability of the product for the purpose for which it is intended, and shall conform to the following requirements:
1. Cast iron casings shall be of close-grained gray cast iron, conforming to ASTM A 48, or equal.
 2. Anchor bolts, nuts, and washers shall be hot-dip galvanized, unless otherwise indicated in individual equipment specifications.

2.03 APPURTENANCES

- A. Nameplates: Each blower, compressor, vacuum pump, and motor shall be equipped with a stainless-steel nameplate indicating rated head and capacity, impeller size, speed, and manufacturer's name, serial, and model number. Nameplates for electric motors shall be in accordance with Section 26 05 10 - Electric Motors.
- B. Solenoid Valves: Solenoid valves shall be provided on the water or oil lubrication and cooling lines. Solenoid valve electrical rating shall be compatible with the motor control voltage and shall be provided complete with all necessary conduit and wiring installation from control panel to solenoid.

- C. Gauges: Blowers, compressors, and vacuum pumps shall be equipped with pressure or vacuum gauges, respectively, installed in the discharge lines. Pressure gauges shall be located in a representative location, where not subject to shock or vibrations, in order to achieve true and accurate readings. Pressure gauges shall conform to Section 40 73 00 – Pressure, Strain, and Force Measurement. Where subject to shock or vibrations, the pressure gauges shall be wall-mounted or attached to galvanized channel floor stands and connected by means of flexible connectors.
- D. Controls shall be in accordance with Section 40 61 96 – Process Control Descriptions.
- E. Electric Motors: Electric motors shall comply with the requirements of Section 26 05 10 - Electric Motors.
- F. Lubrication: Blowers, compressors, vacuum pumps, and motors shall be oil- or grease-lubricated per individual specifications.
- G. Drains: Cooling water drains and drains from variable speed drive equipment shall be piped to the nearest floor sink or drain with galvanized steel pipe or copper tube, properly supported with brackets.
- H. Accessories: Air tool fittings compatible with surge tank re-charge ports shall be provided. Air hoses shall be provided., hosing shall be long enough to reach all surge tank connection points for filing purposes. Contractor to coordinate with surge tank supplier for confirmation of compatibility and adequate hose length.
- I. Additional air compressor accessories shall include air chuck for hand tools with standard connection types, and quick-connects as required by OWNER. Air hose hanger, suited for housing full length of air hose, shall be provided and installed by contractor on wall adjacent to air compressor. Air hose hanger shall not impede on walking area or compressor access.

2.04 TOOLS AND SPARE PARTS

- A. Tools: Special tools necessary for maintenance and repair of the equipment and one pressure grease gun for each type of grease required for blowers, compressors, and motors shall be furnished as a part of the Work hereunder; such tools shall be suitably stored in metal toolboxes and identified with the equipment number by means of stainless steel or solid plastic name tags attached to the box.
- B. Spare Parts: The Contractor shall furnish spare parts subject to wear, such as seals, packing, gaskets, nuts, bolts, washers, wear rings, etc., as well as a set of spare bearings, and one year's supply of filter elements. Furnish parts suitably packaged and labelled in a box as described above for tools.

2.05 MANUFACTURERS

- A. Ingersoll Rand
- B. Or equal

PART 3 -- EXECUTION

3.01 INSTALLATION

- A. General: Blowers, compressors, and vacuum pump equipment shall be installed in accordance with the Shop Drawings and as indicated. General installation requirements shall be as indicated in Section 46 10 00 – Equipment General Provisions.
- B. Alignment: Equipment shall be field tested to verify proper alignment and operation as indicated, and freedom from binding, scraping, excessive noise, overheating, vibration, shaft runout, or other defects. Drive shafts shall be measured just prior to assembly to ensure correct alignment without forcing. Equipment shall be secure in position and neat in appearance.
- C. Piping and Mounting: Piping shall be provided with sufficient expansion joints, guides, and anchors and be supported to preclude the possibility of exerting undue forces and moments on the equipment flanges. Suitable flexible connectors shall be provided to isolate the equipment from the piping system. Each unit shall be mounted on a flat and level concrete pad capable of supporting the dead weight of the unit, by means of restrained vibration isolators or resilient pads of suitable design.
- D. Lubricants: The installation work shall include furnishing the necessary oil and grease for initial operation and for one year's operation.

END OF SECTION

SECTION 43 20 00 – PUMPS, GENERAL

PART 1 -- GENERAL

1.01 SUMMARY

- A. Provide pumps and pump systems appurtenances, complete and operable, as indicated in accordance with the Contract Documents.
- B. The provisions of this Section shall apply to pumps and pumping equipment throughout the Contract Documents, except where otherwise indicated.
- C. Unit Responsibility
 - 1. The PUMP SUPPLIER shall be made responsible for furnishing the pumps and drives; motors, engines, gears and Variable Frequency Drives (VFDs) as one package and for the coordination of design, assembly, and applicable testing of the Work of each specific pump Section. The PUMP SUPPLIER shall specifically note that the VFDs shall be furnished proprietary. See Section 26 29 25 – Variable Frequency Drive Units for details.
 - 2. The PUMP SUPPLIER shall be responsible to the OWNER for compliance with the requirements of each specific pump Section.
- D. Single Manufacturer
 - 1. Where 2 or more pump systems of the same type or size are required, provide pumps produced by the same pump manufacturer.
 - 2. Where multiple pumps are of the same size and type, all parts shall be interchangeable and fit including spare parts.

1.02 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

A. Abbreviations and Acronyms

- 1. NPSHr - Net Positive Suction Head Required
- 2. VFDs - Variable Frequency Drives

B. Reference Specifications

01 33 00	Submittal Procedures
01 77 00	Project Closeout
26 05 10	Electric Motors
26 29 23	Variable Frequency Drive Units

C. Reference Standards

American Society of Mechanical Engineers (ASME)	
ASME B16.1	Cast Iron Pipe Flanges and Flanged Fittings
ASME B16.5	Pipe Flanges and Flanged Fittings

ASTM International (ASTM)	
ASTM A 36	Medium Carbon Steel for fabricated steel bases
ASTM A 48	Gray Iron Castings
ASTM B 148	Standard Specification for Aluminum-Bronze Sand Castings
ASTM A 276	Hot Rolled Annealed and Pickled Stainless Steel Shafts
ASTM A705	Age-Hardening Stainless Steel Forgings
ASTM B148	Aluminum Bronze Sand Castings
ASTM B140	Copper-Zinc-Lead (Red Brass or Hardware Bronze)
ASTM B 584	Standard Specification for Copper Alloy Sand Castings for General Applications
International Organization for Standardization (ISO)	
ISO 9000	Quality management systems - Fundamentals and Vocabulary
ISO 9001	Quality management systems – Requirements.
ISO 1940-1	Mechanical Vibration – Balance Quality Requirements for Rotors in a Constant (Rigid) State - Part 1: Specification and Verification of Balance Tolerances
American National Standards Institute /Hydraulic Institute (ANSI/HI)	
ANSI/HI 3.1- 3.5	Rotary Pumps for Nomenclature, Definitions, Application and Operation
ANSI/HI 3.6	Rotary Pump Tests
ANSI/HI 4.1- 4.6	Sealless, Magnetically Driven Rotary Pumps for Nomenclature, Definitions, Application, Operation, and Test
ANSI/HI 5.1- 5.6	Sealless, Rotodynamic Pumps for Nomenclature, Definitions, Application, Operation, and Test
ANSI/HI 6.1-6.5	Reciprocating Power Pumps for Nomenclature, Definitions, Application, and Operation
ANSI/HI 6.6	Reciprocating Pump Tests
ANSI/HI 9.1 – 9.5	Pumps General Guidelines
ANSI/HI 9.6.1	Rotodynamic Pumps – Guideline for NPSH
ANSI/HI 9.6.2	Rotodynamic Pumps for Assessment of Applied Nozzle Loads
ANSI/HI 9.6.3	Rotodynamic Pumps – Guidelines for Operation Regions
ANSI/HI 9.6.4	Rotodynamic Pumps - Guidelines for Vibration Measurements and Allowable Values
ANSI/HI 9.6.6	Rotodynamic Pumps - Guidelines for Pump Piping
ANSI/HI 9.6.8	Rotodynamic Pumps – Guidelines for Dynamics of Pumping Machinery
ANSI/HI 9.8	Rotodynamic Pumps for Pump Intake Design
ANSI/HI 14.1-14.2	Rotodynamic Pumps for Nomenclature and Definitions
ANSI/HI 14.3	Rotodynamic Pumps for Design and Application

ANSI/HI 14.6	Rotodynamic Pumps for Hydraulic Performance Acceptance Test
ANSI/HI 40.6	Methods for Rotodynamic Pump Efficiency Testing
National Sanitation Foundation/American National Standards Institute (NSF)	
NSF/ANSI 61 -	Drinking Water System Components – Health Effects

1.03 PUMP SUPPLIER SUBMITTALS

A. Product Data

1. Furnish submittals in accordance with the requirements of Section 01 33 00 – Submittal Procedures.

B. Shop Drawings

1. Submit shop drawings, product data, and general arrangement drawings for pumps as specified in Part 2 – Products.
2. Submit Rotodynamics and Structural Analysis as specified in Part 2 – Products.
3. Submit material testing procedures and Test Certificate as specified in Part 3 – Execution.
4. Anchorage calculations and required documentations.
5. Submit factory performance and functional Test Plan as specified in Part 3 – Execution.
6. Submit Installation Procedure prior to shipment as specified in Part 3 – Execution.
7. Submit Operation and Maintenance Manual prior to shipment as specified in Part 3 – Execution.
8. Submit Certificate of Inspection after receipt of shipment at job site.
9. Submit Certificate of installation as specified in Part 3 – Execution.
10. Submit Certificate of Inspection after completion of Operational Readiness Testing as specified in Part 3 - Execution
11. Submit Plant Operation and Maintenance Training Lesson Plan and schedule as specified in Part 3 – Execution.
12. Submit Certificate of Successful Trial Functional Dry Testing as specified in Part 3 Execution.
13. Submit Certificate of Successful Final Performance Verification and Functional Wet Testing as specified in Part 3 - Execution.

C. Technical Manual

1. Submit a Technical Manual containing the required information indicated in Section 01 33 00 – Submittal Procedures and each specific pump Section.

D. Spare Parts List

1. Submit a spare parts list containing the required information indicated in Section 01 33 00 – Submittal Procedures and each specific pump Section.

E. Factory Test Data

1. Pumps shall be factory tested. Submit layout drawing of factory test setup showing the pump, drive, piping diameter and lengths, locations of valves, instruments and test procedures and valid calibration certificates of test instruments.
2. Submit signed, dated, and certified factory test data for each pump system. No equipment shall be shipped until the test data have been approved by the ENGINEER.

F. Certifications

1. Submit the manufacturer's certification of proper installation.

G. Certificates

1. Certificate of Factory Performance Test by manufacturers for pumps, motors, and VFDs.
2. Certificate of proper installation of pump system signed by the manufacturer and Contractor.
3. Certificate of Field affirmation performance testing signed by the manufacturer and Contractor.

H. Delegated Design Submittals

1. If required by the specification Section, submit Lateral, Torsional and Structural analysis analyses signed by registered professional engineer.

I. Test and Evaluation Reports Submittal

1. Factory performance test report for pumps, motors and VFDs.
2. Shaft material mill certificate and casting material testing report if required in each specification Section for large pumping equipment.
3. Nondestructive Testing procedures and certificate of materials report if required in each specification Section for large pumping equipment.

J. Manufacturers' Instructions

1. Equipment handling, shipping, and storage instructions by manufacturers.
2. Installation instructions by manufacturers.
3. Startup and commissioning instruction by manufacturers.

K. Source Quality Control Submittals

1. Foundry casting quality control documents if required in equipment specification section for large pumping equipment.
2. Source quality documentation of shafting if required in equipment specification section for large pumping equipment.
3. Statement by manufactures indicating adherence to quality procedures per ISO 9001.

L. Manufacturer Reports

1. Submit manufacturer's production schedule and report, if required in equipment specification section.
2. Submit manufacturer's factory testing report for all pump system equipment.
3. Submit field vibration testing report conducted by the CONTRACTOR and PUMP SUPPLIER and witnessed by the ENGINEER.

M. Sustainable Design Submittals

1. Submit sustainable design and calculations if required in the contract document.

N. Special Procedure Submittals

1. Submit special installation and startup procedures.

O. Qualification Statements

1. Submit resume of specialist engineer who will perform torsional, lateral and structural analysis.
2. Submit resume of factory trained installation and start-up representative.

1.04 CLOSEOUT SUBMITTALS

A. Submit closeout documents specified in Section 01 77 00 – Project Closeout .

B. Maintenance Contracts

C. Operation and Maintenance Data

1. Submit Operation and Maintenance Manuals necessary for the work as part of process equipment provisions. Include video when required for OWNER's instructions. Coordinate with Section 01 77 00 – Project Closeout

D. Warranty Documentation

1. Submit final executed warranty documents for pumping equipment and coordinate with Section 01 77 00 – Project Closeout.

E. Record Documentation

1. Submit record drawings and specifications of record documentation specific to include items such as annotated drawings, Project Manuals, and submittals and samples, marked up to indicate the actual products used and locations of concealed work or utilities. This may include periodic or final update of a Building Information Model (BIM) by the Contractor. Coordinate with Section 01 77 00 – Project Closeout.

1.05 MAINTENANCE MATERIAL SUBMITTALS

A. Spare Parts

1. In addition to the list of spare parts listed in each pump specification Section, include list of recommended spare parts, name, part number, number of units, cost and source location, address, contact names and phone numbers.

B. Tools

1. Submit list of tools specified in each Section.
2. Submit list of recommended tools and cost for use to maintain equipment.
3. Submit list of special tools unique to the equipment supplied in the project.

1.06 QUALITY ASSURANCE

A. Regulatory Agency Sustainability Approvals.

B. Submit Quality Assurance procedures applicable to foundry, machine shop, testing, handling, delivery, installation, and startup.

C. Qualifications

1. Submit resume of manufacturer representative proposed to supervise field installation and startup.
2. Submit resume of manufacturer representative who will conduct operation and maintenance training of Owners Operation and Maintenance personnel.

1.07 DELIVERY, STORAGE, AND HANDLING

A. Storage and Handling Requirements

1. Care shall be taken in loading to prevent injury to the pumps, drives and appurtenances, or coatings.
2. Prior to shipping, the ends of all equipment shall be acceptably covered to prevent entry of foreign material. Covers shall remain in place until after installation and connecting piping is completed.

1.08 WARRANTY

A. Manufacturer Warranty: Section 01 78 36 – Warranties.

PART 2 -- PRODUCTS

2.01 SEE SPECIFIC EQUIPMENT SPECIFICATION SECTIONS.

PART 3 -- EXECUTION

3.01 SEE SPECIFIC EQUIPMENT SPECIFICATION SECTIONS.

END OF SECTION

SECTION 43 23 21 – HORIZONTAL SPLIT-CASE PUMPS

PART 1 -- GENERAL

1.1 SCOPE

- A. The PUMP SUPPLIER shall furnish three (3) horizontal split-case pumps, for the specified service indicated, including all appurtenances. As a minimum this shall include but not be limited to: pumps, motors, baseplates, couplings and guards; complete and operable, in accordance with the Contract Documents.
- B. Unit Responsibility: A single pump manufacturer shall be responsible for furnishing the pumps and motors, to the CONTRACTOR; and for coordination of design, assembly, testing, and installation of each pump system. Each pump shall be produced and assembled by the manufacturer at a facility owned or operated by the manufacturer and under the direct supervision and control of the manufacturer. The CONTRACTOR will furnish and/or coordinate all components and accessories as necessary to place the equipment in operation in conformance with the specified performance, features and functions described implicitly herein or implied. CONTRACTOR shall coordinate between PUMP SUPPLIER and VFD SUPPLIER for confirmation of equipment compatibility
- C. The selection of the ratings of motor shall be coordinated by the pump manufacturer to insure compatibility of the pump and motor as a system.
- D. The VFDs shall be furnished by a proprietary supplier. See Section 26 29 23 – Variable Frequency Drive Units for details. Note that a complete spare VFD shall be provided in addition to the VFDs for the individual pumps.

1.2 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

- A. The requirements of Section 01 33 00 – Submittal Procedures apply to this Section.
- B. The requirements of Section 26 00 10 – Electrical General Requirements, apply to this Section.
- C. Motors supplied as part of the pump systems shall comply with Section 26 05 10 – Electric Motors.
- D. VFDs shall meet the requirements of Section 26 29 23 – Variable Frequency Drive Units.
- E. The requirements of Section 43 20 00 - Pumps, General apply to this Section.
- F. The requirements of Section 46 01 00 - Equipment General Provisions apply to this Section.
- G. Design, manufacturing, and assembly of elements of the equipment herein specified shall be in accordance with, but not limited to, published standards of the following, as applicable:
 - 1. American National Standards Institute (ANSI)
 - 2. American Society for Testing and Materials (ASTM)
 - 3. American Bearing Manufacturers Association (ABMA)

4. Hydraulic Institute Standards (current edition)
5. National Electrical Manufacturers Association (NEMA)

H. Where reference is made to one of the above standards, the revision in effect at the time of bid opening shall apply.

1.3 MANUFACTURER QUALIFICATION

- A. Manufacturer shall have continuous experience in the manufacture of horizontal split-case pumps for the past 10 years with connected load of not less than 150 horsepower and comparable flow capacity of the pumps required for this project.
- B. Manufacturer shall have a local service facility or an independent service facility fully trained, commissioned, and located in the state of Ohio, or must be prepared to provide factory-certified service from a service facility in the United States within 48 hours, inclusive of weekends and holidays.
- C. Manufacturer's service facility shall have a minimum of the past five years of continuous experience in successful field installation, service installation, alignment, parts replacement, and stocking parts of pumps of the same size or larger than the units specified in these Contract Documents.

1.4 PUMP SUPPLIER SUBMITTALS

A. **General:** Submittals shall be furnished in accordance with the requirements of the Section 01 33 00 – Submittal Procedures, Section 43 20 00 – Pumps, General, Section 46 01 00 - Equipment General Provisions, and the requirements specified in this section.

B. **Shop drawings shall include the following:**

1. Certified dimensional drawings of each item of equipment and auxiliary apparatus to be furnished, including equipment weights and location and size of anchor bolts.
2. Literature and drawings describing the equipment, including parts list and materials of construction, in sufficient detail to indicate full conformance with the specifications.
3. Motor performance data, wiring diagrams, one-lines, and conduit entry dimensions and details in accordance with Section 26 05 10 – Electric Motors.
4. VFD information in accordance with Section 26 29 23 – Variable Frequency Drive Units.
5. Cut sheets on accessory items.
6. Manufacturer's certified rating curves, to satisfy the specified design conditions, showing pump characteristics of discharge, head, brake horsepower, efficiency and guaranteed net positive suction head required (NPSHR). When applicable, variable speed curves shall be provided showing at least three speeds plotted equally from maximum rpm to minimum rpm. Minimum rpm shall be no less than that required to obtain minimum flow. Curves shall show the full recommended range of performance and include shut off head. This information shall be prepared specifically for the pump proposed. Catalog sheets showing a family of curves will not be acceptable.

C. **Operation and Maintenance Data:**

1. Complete operating and maintenance instructions shall be furnished in accordance with Section 01 33 00 – Submittal Procedures. The maintenance instructions shall include troubleshooting data and full preventative maintenance schedules and complete spare parts lists with ordering information.
2. Include certified performance data and curves from factory tests.

1.5 SERVICES OF MANUFACTURER

A. Coordination of Design, Inspection, Start-up, Training, and Field Adjustment.

1. An authorized representative of the manufacturer shall visit the Site and perform the following:
 - a. Minimum of one (1) (8-hour days) site visit for installation guidance.
 - b. Minimum of three (3) (8-hour days) with one (1) trip for on-site inspection, certification of installation, classroom training for equipment instruction and maintenance.
 - c. Minimum of one (1) (8-hour days) for pump equipment software integration guidance onto SCADA system and configuration of pump protection unit.
 - d. Authorized representative shall submit summary report for each day on site to CONTRACTOR. CONTRACTOR will forward reports to OWNER.
2. Workdays shall be Monday through Friday with the hours and dates established by the CONTRACTOR. Installation and start-up dates shall be established by the CONTRACTOR and OWNER.

B. **Instruction of OWNER'S Personnel:** The PUMP SUPPLIER shall submit a one (1) copy of the training manual written in English to the OWNER for approval. Training shall not commence until 20 days after written approval by the OWNER and shall be scheduled at least 15 days prior to start-up. All trainees, minimum of 4, shall receive a training manual specific to their trade as follows:

1. Mechanics
2. Electricians
3. Instrument Technicians
4. Operators

C. The training manuals will be retained by the trainees, not returned to the manufacturer. The manuals shall be complete with the approved shop drawings, operation, and maintenance and troubleshooting.

D. Instruction of Owner's Personnel:

1. Qualified training representatives, approved in writing by the OWNER, shall visit the site to instruct the OWNER's personnel in the operation and maintenance of the equipment, including step-by-step troubleshooting with necessary test equipment. Instruction shall be specific to the models of equipment provided.

2. Training shall be scheduled three weeks in advance of the scheduled session, at a date mutually agreeable by the OWNER, manufacturer, and Sub-suppliers.
3. Proposed training material and a detailed outline of each lesson shall be submitted for review. Review comments from the OWNER shall be incorporated into the material prior to the training sessions.
4. The training materials shall remain with the trainees after the session.
5. OWNER's personnel shall be trained in the operation and maintenance of the pumps for a minimum 8 hours.

1.6 EQUIPMENT WARRANTY AND GUARANTEES

- A. The PUMP SUPPLIER shall warrant that the pumps, with all their main, appurtenances, and control systems, will be free from defects in design, material, and workmanship in accordance with Section 01 61 10 – Equipment Pre-Procurement – General.
- B. The PUMP SUPPLIER shall repair or replace, at the sole option of and at no cost to the PURCHASER, WORK found to be defective within said warranty period.

1.7 QUALITY ASSURANCE

- A. The equipment specified herein is intended to be of proven ability as manufactured by concerns having extensive experience in the production of such equipment. The equipment furnished shall be designed, constructed, and installed to operate satisfactorily when installed as shown on the Contract Drawings. Pumps shall be manufactured in accordance with the Hydraulic Institute Standards, except where otherwise specified herein.
- B. The pump manufacturer shall be fully responsible for the design, arrangement and operation of all connected rotating components as assembled and mounted on a fabricated steel base to ensure that neither harmful nor damaging vibrations occur at any speed within the specified operating range.
- C. Vibration, when measured in the direction of maximum amplitude on the pump and motor bearing housings, shall not exceed limits given in the latest ANSI/HI nomograph for the applicable pump type.

1.8 TEST REPORTS

- A. Complete, certified test reports of all factory testing shall be submitted to the ENGINEER for approval. Written approval is required prior to shipment of any pump.

PART 2 -- PRODUCTS

2.1 GENERAL DESCRIPTION

- A. Identification

Pump Name	
Equipment number	P-101, P-102, and P-103

Quantity	3 (Also provide a spare VFD – see Section 26 29 23)
Location	Booster Pump Station

- B. **Operating Conditions:** The WORK of this Section shall be suitable for long term operation under the following conditions:

Duty	Continuous
Drive	Variable Speed
Ambient temperature, degrees F	45 to 85
Ambient relative humidity, percent	30 to 100
Fluid service	Finished Water
Fluid temperature, degrees F	60
Fluid pH range	6 - 9
Fluid specific gravity	1.0
Fluid viscosity, absolute centipoises at 60 deg F	1.0
Pump Resting elevation	889
Minimum available NPSH, ft absolute	127
Pump removal method	Bridge Crane
Power supply	480-volt 3-phase 60 Hz

- C. Pump Performance Requirements

Pump Hydraulic Requirements	Description
Minimum shutoff head, ft	170
Design flow capacity, gpm @ Total Dynamic Head, Ft.	3,000 @ 140
Design flow minimum wire-to-water pump efficiency, percent	79
Design flow, maximum NPSH required, ft.	30

Maximum flow capacity at maximum speed, GPM @TDH, Ft. plus/minus 3 ft	3,750 @ 110
Maximum flow minimum pump efficiency, percent	74
Maximum flow NPSH required, ft absolute	42
Minimum flow capacity at maximum speed, GPM @TDH, Ft. plus/minus 3 ft	2,083 @ 84
Minimum flow pump efficiency, percent	50
Maximum pump/motor speed, rpm	1800
Maximum motor size, Motor hp	150

D. Pump Dimensions

Description Dimensions	Pump Dimensions
Size of discharge flange, inches	8
Size of suction flange, inches	10
Flange rating	125 lb

2.2 PUMP REQUIREMENTS

A. General

1. The pumping units shall all be supplied by one manufacturer and shall be complete including pumps, motors, baseplates, couplings, guards and other accessories as specified herein.
2. The pumps, motors, drives, couplings and base plates shall be designed and built for 24-hour continuous service at any and all points within the specified range of operation, without overheating, without damaging cavitation, and without excessive vibration or noise.
3. Each major piece of equipment shall be furnished with a stainless steel nameplate (with embossed data) securely mounted to the body of the equipment. As a minimum, the nameplate for the pumps shall include the manufacturer's name and model number, serial number, rated flow capacity, head and speed. As a minimum, nameplates for motors shall include the manufacturer's name and model number,

serial number, horsepower, speed, input voltage, amps, number of cycles, power, and service factors.

4. Pumps shall include an additional nameplate displaying NSF-G Certification.

B. Pump Construction: Construction of horizontal split-case pumps shall conform to the following requirements:

1. The casing shall be of close-grained ASTM 278 Class 25 cast iron and hydro tested to 1.5 times the casing working pressure. Casing shall be split on the horizontal center line with suction nozzles, discharge nozzles and feet cast integrally with the lower half. The casing halves shall be accurately located with straight dowel pins to eliminate mismatch. The upper half of the casing shall be removable without disturbing pipe connections or pump alignment. Single volute casings are acceptable if they are manufacturers standard for given sizes. The casing shall be supplied with all necessary vents, drains and gage connections.
2. The impeller shall be made of 316 stainless steel or bronze, and be enclosed double suction type. Impeller material shall meet NSF-61 requirements. The impeller shall be machined and polished to perform with maximum efficiency. Each impeller shall be dynamically balanced to ISO-1940; Grade 6.3 in order to minimize vibration and improve bearing life. The impellers shall be keyed to the shaft and secured at the hub between the shaft sleeves extending through the stuffing box with shaft nuts external to the stuffing box. Single suction impellers are acceptable if they are manufacturers standard for smaller pumps provided they are hydraulically balanced by design.
3. Furnish 416 stainless steel, 316 stainless steel, or bronze wear rings. Wear and casing ring materials shall be compatible. The casing ring shall be designed to provide a smooth water flow onto the impeller eye. The impeller ring shall be locked with a positive means to prevent rotation.
4. Stuffing boxes shall be integrally cast with the pump casing. A large opening shall be provided adjacent to the stuffing box to facilitate packing or mechanical adjustment and replacement. The seal shall have carbon/silicon carbide or silicon carbide/silicon carbide faces per the NSF 61 certification.
5. Suction and discharge flanges shall be integrally cast with the lower casing half and orientated 180 degrees from each other. No handholes shall be provided.
6. Pump shafts shall be 416 stainless steel per NSF 61 certification. On packed pumps, the shaft shall be protected from wear and erosion by removable sleeves secured at opposite ends with shaft sleeve nuts or retaining rings. The shaft shall have the same nominal diameter from one shaft sleeve locknut to the other to minimize fatigue failures due to stress concentrations. Maximum shaft deflection at the stuffing box face shall not exceed .002" at 25% of BEP.
7. The pump bearings shall be heavy duty, single row, deep-groove type ball bearings, arranged for oil or grease lubrication. Sealed for life bearings are not acceptable. They shall be designed and sized for at least 100,000 hours calculated minimum L10 rated bearing life at 25% BEP per ANSI B 3.15. Each bearing shall be capable of carrying both line and thrust type loads. The thrust bearing shall be securely held to the shaft. Inboard and outboard bearing interchangeability is preferred.

8. Removable bearing houses shall be provided with bearing brackets cast separate and accurately machined and doweled to the casing.
9. Provide ½" FNPT taps on the spring line of the suction and discharge sections of the lower casting for pressure gauges.

2.3 MOTOR AND VFD

- A. Each pump shall be driven by a horizontal variable speed squirrel cage induction electric motor with a maximum horsepower and speed as specified above. The pump motors shall be suitable for driving the pumps continuously over the entire pumping range. The pump motors shall be furnished by the pump manufacturer.
- B. Each pump shall be directly connected to its driver by means of a Falk; Fast's or equal all metal coupling, suitably sized to transmit the required driving torque and to accommodate unavoidable shaft misalignment.
- C. Motors shall be designed for continuous duty in non-hazardous locations. Motors shall have TEFC enclosures with a combined service factor (combined effect of voltage, frequency, and specific gravity) of 1.15 (sine)/1.0 (inverter) or greater. Motors shall meet the requirements of Section 26 05 10 – Electric Motors.
- D. The motor shall be non-overloaded at 1.0 service factor at any point in the design operating range of the pump, including run-out and shut-off. The total capacity of the motor (name plate rating) shall not be exceeded while the pump is operating at any point on the characteristic curve. The service factor shall not be used as part of the motor rating.
- E. The VFDs shall be furnished by the VFD SUPPLIER and shall meet the requirements of Section 26 29 23 – Variable Frequency Drive Units. Provide one (1) VFD for each pump and one (1) complete spare VFD. CONTRACTOR shall coordinate between PUMP SUPPLIER and VFD SUPPLIER for confirmation of equipment compatibility.

2.4 BASEPLATES

- A. The pump and motor shall be mounted on an extended fabricated steel baseplate with provision to collect leakage and of sufficient size and rigidity to support the unit and prevent harmful vibration. The steel base shall be anchored to the level surface of a concrete pad with suitably sized Type 316 stainless steel anchor bolts.
- B. The pump manufacturer shall factory mount and rough align motors on baseplates. Final alignment will be done by the CONTRACTOR in the field. Motors may be dismantled for shipment.

2.5 PRESSURE GAUGES

- A. Pressure gauges for the suction and discharge of each pump (quantity two (2) gauges per pump provided) shall be provided by the PUMP SUPPLIER for installation by the CONTRACTOR in accordance with the detail installation.
- B. Pressure gauges shall be 4-1/2 inches in diameter, liquid-filled, bottom-connected, with white laminated dials and black graduation. Windows shall be shatterproof glass. Gauges shall have a blowout disc and be encased in phenolic, steel or cast iron. Measuring element shall be a stainless-steel bourdon tube with welded, stress-relieves

joints. Socket shall have wrench flats. Movement shall be rotary geared, all stainless-steel material. All pressure gauges shall be provided with a pulsation snubber constructed of 316 stainless steel and a ball isolation valve. Accuracy shall be plus or minus 0.5 percent range to 150 percent of the working pressure or vacuum of the pipe or vessel to which they are connected.

C. Pressure gauges shall be as manufactured by:

1. Ashcroft 1279
2. Ametek Solfrunt Series 1900
3. Or approved equal.

2.6 SURFACE PREPRATION AND SHOP PRIME PAINTING

A. Each fabricated steel base mounted pumping unit, including base and guard, shall be shop primed in accordance with manufacturers standard paint procedure. The shop primer shall be compatible with the Contractors finish paint.

1. Contractor finish paint will be 2 component epoxy primer and finish with a maximum VOC content of 100 g/L. Prime coat will be a dry film thickness (DFT) of 4-5 mils and finish coat will be a DFT of 4-5 mils for a total system DFT of 8-10 mils. The acceptable manufacturers will be: PPG Amerlok 2/400 VOC, Tnemec Series L69, Carboline Carboguard 890 VOC, or Sherwin-Williams Macropoxy 646-100.

B. The pump casing interior surfaces shall be coated with Series 21 Pot-a Pox.

C. Motors shall have manufacturer's standard finish paint for corrosive environments.

2.7 SPARE PARTS

A. General: The pumps shall be backed by supplies of spare parts from stock, and after-sales service from a factory trained and authorized maintenance facility, located within 500 miles from the Site.

B. Furnish the following spare parts:

1. One (1) impeller
2. One (1) set of impeller wear rings
3. One (1) set of casing wear rings
4. One (1) set of pump bearings
5. One (1) set of bearing housings
6. One (1) set of shaft sleeves with keys, nuts, and O-rings
7. One (1) set of all gaskets
8. One (1) mechanical seal repair kit; and

9. One (1) complete set mechanical seals

2.8 FACTORY TESTING AND SHIPMENT

- A. In addition to the factory tests in Section 43 20 00, the following procedures shall be included with the factory test prior to shipment:
 1. A complete test report for each pump, including certified characteristic curves of the pump, consisting of at least all information required above, except for NPSHR, and certified copies of the hydrostatic test report, shall be submitted to and approved by the ENGINEER before the pumps are shipped.
 2. Each pump specified herein shall be factory tested in accordance with the latest edition of the Hydraulic Institute Standards. Notification of such test and a list of test equipment and procedures shall be furnished to the ENGINEER at least 10 working days before the schedule test date.
 3. Tests shall be run on a closed loop with a factory calibrated test motor.
 4. A minimum speed curve shall be plotted on the performance curve based on the pump affinity laws and the test data.
 5. Verification of cavitation-free service and absence of motor overheating during conditions simulating the actual operating conditions after installation.
 6. All gauges and other test instruments shall be calibrated within 30 days of the scheduled test and certified calibration data shall be provided. All Venturi flow meters shall be calibrated as required by ANSI/HI standards.
- B. Parts shall be properly lubricated and protected so that no damage or deterioration will occur even during a prolonged delay from the time of shipment until installation is completed and the pumps are ready for operation.
- C. Finished ferrous surfaces not painted shall be properly protected to prevent rust and corrosion.
- D. Each pump shall be properly crated to protect against damage during shipment. The CONTRACTOR will store equipment in accordance with the manufacturer's written instruction.

2.9 MANUFACTURERS

- A. Fairbanks Nijhuis
- B. Flowserve
- C. Peerless Pumps

PART 3 -- EXECUTION

3.1 SCHEDULE

- A. PUMP SUPPLIER shall coordinate the schedule of services such as assistance with installation, testing, start-up, and training with the CONTRACTOR to avoid conflicting with other onsite construction, testing, or other manufacturer's onsite services.

3.2 INSTALLATION AND INSPECTION

- A. General: CONTRACTOR to install pumps. The PUMP SUPPLIER shall submit the recommended installation procedure. Each pump shall be factory pre-assembled, aligned, and checked for proper alignment.
- B. Manufacturer's representative shall witness installation of the equipment and certify in writing the following:
 - 1. Equipment, wiring, and controls have been properly installed, aligned, lubricated, adjusted, and readied for operation.
 - 2. Inspected, checked, and performed field adjustments to ensure that the equipment installation and operation comply with requirements.
 - 3. Supervise equipment installation.
 - 4. Supervise alignment of equipment.
 - 5. Supervise grouting of equipment.
 - 6. Complete the Manufacturer's Certificate of Proper Installation.
 - 7. Manufacturer's representative shall be at site as long as necessary to complete this task, and longer if necessary to coordinate with the other equipment furnished under this Contract.

3.3 START UP, FIELD ADJUSTMENT, AND FIELD TESTING

- A. The CONTRACTOR and the PUMP SUPPLIER shall conduct field tests with the equipment manufacturer's representative in the presence of the OWNER on all pumps and motors as described herein. The pumps shall be tested in accordance with the latest edition of the Hydraulic Institute Standards. The OWNER may require that the inspection, startup, and field adjustment services above be extended as required to complete the startup services

3.4 SERVICES OF MANUFACTURER

- A. **Inspection, Startup, and Field Adjustment:** The service representative of the manufacturer shall be present at the Site to furnish the services required by Section 43 20 00 – Pumps, General.

END OF SECTION

SECTION 43 42 21 – BLADDER TYPE SURGE TANK

PART 1 - GENERAL

1.1 SCOPE

- A. The work described by this section of specifications consists of furnishing all equipment, materials, and labor to provide, install and test one (1) horizontal bladder-type surge tank for potable water surge control as shown on the Contract Drawings and specified in the Contract Documents.
- B. Bladder type surge tank including:
 - 1. Design of the tank
 - 2. Coordination with Contractor for standard product adjustments
 - 3. Submittals
 - 4. Special tools and maintenance equipment
 - 5. Complete anchorage design and detailing, including anchor rod design, attachment to foundation and attachment to tank
 - 6. Anchor rods and hardware
 - 7. Anchor rod templates
 - 8. Shop fabrication and testing
 - 9. Delivery inspection
 - 10. Installation verification
 - 11. Training
 - 12. Complete design and detailing of pipe supports
 - 13. Warranty

1.2 REFERENCE SPECIFICATIONS

- A. 01 33 00 – Submittals Procedures
- B. 01 33 17 – Structural Design, Support and Anchorage
- C. 01 75 00 – Equipment Testing and Startup
- D. 03 31 00 - Cast In Place Concrete
- E. 09 96 00 – High Performance Coating
- F. 40 73 00 – Pressure, Strain, and Force Measurement

1.3 APPLICABLE CODES AND STANDARDS

- A. NSF61, Drinking Water System Components
- B. ASCE 7-16, Minimum Design Loads and Associated Criteria for Buildings and Other Structures
- C. ASME Boiler and Pressure Vessel Code (BPVC):
 - 1. Section II, Materials
 - 2. Section VIII, Rules for Construction of Pressure Tanks, Division 1
 - 3. Section IX, Welding, Brazing, and Fusing Qualifications

1.4 SUPPLIER SUBMITTALS

- A. See Section 01 33 00 – Supplier Procedures
- B. Additional Submittals
 - 1. Experience
 - a. Summary of experience with carbon steel tank fabrication using similar vessel diameter and design
 - 2. Shop Drawings
 - a. Dimensioned general arrangement/layout drawings with tolerances, including all equipment, accessories, supports, connections, outlets, and all related piping
 - b. Weld locations, types, sizes, and extents using welding symbols recommended by ANSI/AWS A2.4
 - c. Dimensioned template general arrangement drawings
 - d. Pipe support locations and details
 - 3. Anchorage Design
 - a. See Section 01 33 17 – Structural Design, Support and Anchorage
 - b. Design anchors installed in concrete per ACI 318, Chapter 17
 - c. Design anchor chairs per ASCE 7-16
 - d. Anchor design drawings and details
 - e. Anchorage calculations and anchorage design drawings and details signed and sealed by a Civil or Structural Engineer registered in the State of Ohio.
 - 4. NSF 61 Compliance
 - a. NSF 61 certifications for wetted components

5. Informational Submittals
 - a. Quality assurance/ quality control program
 - b. Welding Procedure Specifications, Procedure Qualification Records, and Welder Performance Qualifications in accordance with ASME BPVC Section IX
 - c. AWS D1.6 Certification for all welders
 - d. Cleaning Procedures
 - e. Passivation Procedures
 - f. Shipping, unloading, storage instructions
 - g. Shipping weight
 - h. Operating weight, including liquid (at overflow elevation)
 - i. Written installation instructions
 - j. List of special tools, materials, and supplies
 - k. List of recommended spare parts list for three (3) years of operation
 - l. Schedules for fabrication, factory testing, delivery
6. Factory Inspections Reports per API 650 or ASME, with radiographs
 - a. Manufacturer shall provide inhouse x-rays of welds if ASME code requires it, hydrostatic test, and ASME inspection. The Engineer reserves the right to inspect the vessel manufacturing facility to confirm requirement above.
7. Operations and Maintenance Manuals including
 - a. Maintenance schedules
 - b. Descriptions of operation
 - c. Spare parts information
8. Performance Affidavit
9. SUPPLIER's surge hydraulic analysis report confirming the suitability of the tank capacities and specifications contained herein.
10. Specifications for system components, accessories and protective coating.
11. SUPPLIER Qualifications
12. In-house x-rays of welds, hydrostatic test, and ASME inspection. The Contractor reserves the right to inspect the vessel manufacturing facility to confirm requirement above.

1.5 SHOP TESTING

A. Hydrostatic Testing

1. Hydrostatically test tanks with appurtenances according to the following protocol:
 - a. Seal all connections to the tank except the vent
 - b. Fill the tank with potable water to the highest overflow
 - c. Measure the liquid loss over the next 24-hour period including evaporation
 - d. No visible leaks, water puddles, or damp spots is permitted
2. Retest if any leakage present
3. Fully drain and dry equipment after testing
4. Test pressure shall be a minimum of 150% of the design pressure of the tank.

1.6 QUALITY ASSURANCE

- A. Follow approved Quality Assurance/Quality Control Program
- B. Designate a project manager for the duration of the project to coordinate with the Contractor

1.7 PRODUCT DELIVERY, STORAGE AND HANDLING

- A. Pack and crate equipment for shipment
- B. Cover all vessel holes and seal openings to exclude foreign matter
- C. Identify each component with durable identifying labels or tags securely attached to each piece of equipment, crate or container
- D. Protect finished surfaces of all exposed flanges
- E. Identify temporary shipping braces for removal after assembly.
- F. Package with all required precautions to prevent the tank from recontamination during deliver, storage, and installation. The packaging shall prevent contact between workers and all passivated and cleaned surfaces.

1.8 SUPPLIER QUALIFICATIONS

- A. Supplier shall submit a list of ten (10) U.S. installations of a bladder-type surge tank of size and design conditions similar to the proposed equipment and in successful operation for at least five (5) years. The list shall include OWNER contact names, phone numbers, length of service, and design criteria.
- B. Registered Professional Engineer with at least 5 years of experience in the design and field fabrication of bladder type surge tanks, who will be the responsible engineer in charge of the design

1.9 WARRANTY

- A. Manufacturer shall guarantee that the bladder-type surge tank shall perform as specified and shall warrant the system, complete, to be free from defects in materials and workmanship for a period of two (2) years from the date of Substantial Completion. The bladder-type surge tank manufacturer shall repair or provide replacement for any defective components at no cost to the Owner under this warranty. If the bladder is made of a material other than butyl rubber, that material must be approved by the engineer and the manufacturer must provide a 10-year warranty to replace the bladder and install at no cost to the owner.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

- A. Charlotte
- B. Or equal
- C. The SUPPLIER shall be ISO-9001 certified which includes engineering, design, manufacturing and testing complete components. Vessel SUPPLIER shall manufacture their own vessels and within the same plant as per quality control through ISO.

2.2 GENERAL

- A. The horizontal bladder-type surge tank shall be provided with the manufacturer's services at the jobsite at no additional cost to the Owner. One full 8-hour day of service from manufacturer's representative shall be provided per tank to approve the tank installation and advise the Contractor during startup, testing, and final adjustment of each tank. In addition to this day, one additional full 8-hour day shall be provided in a separate trip to instruct the Owner's personnel in the operation and maintenance of the tank system.
- B. The size of the surge tanks specified herein shall be confirmed by the bladder-type surge tank SUPPLIER using a hydraulic analysis.
- C. Anti-Extrusion system shall be installed at the tank connection point to the system to prevent bladder extrusion.

2.3 SURGE TANK

- A. The tank shall be a horizontal, bladder-type vessel suitable for use with potable water. Tank shall be a Charlotte HCA Hydrochoc model/60,000L – 150psi, bladder type horizontal surge tank.
- B. The sizing of the surge bladder tank shall be based on the hydraulic analysis performed by the tank manufacturer.
- C. Minimum Volume of 16,000 gallons and a 118" diameter and 370" length is required.
- D. Structural Design and Supports shall include the tank, supports, and anchor bolts shall be designed based upon local building codes in addition to the following criteria:
 - 1. Design for a hydrostatic operating pressure of 85 psi and a maximum allowable working pressure of 150 psi and hydrostatic test pressure of 225 psi.

2. Support tank by support legs (four minimum) for attaching to a concrete floor or slab. Material of construction shall comply with ASTM A 36 or ASTM A 285, Grade C. Weld the support legs to the tank.
3. Seismic Design Parameters to conform to the current IBC (if necessary and required by design engineer).
4. Wind Design Parameter to conform to the current IBC (if necessary and required by design engineer).

E. Surge Tank Design and Materials

1. Materials for the tank, design, and shop fabrication and inspection shall comply with Section VIII, Division 1, of the ASME Boiler and Pressure Vessel Code with only the plate steels in Table UCS-23 of said code being used. Provide ASME code stamp, National Board Registration number and pressure rating on tank.
2. Minimum design pressure shall be as stated in this section of the Specifications. Perform hydrostatic testing in shop. Test pressure shall be 150% of the design pressure of the tank.
3. The surge tank HCA Hydrochoc model// 60,000L – 150 psi, the bladder, the paint, the tank, and the entire tank model shall be NSF-61 approved, and listed on the NSF database, for use with potable water applications. Proof of NSF listing of the entire tank model shall be submitted to the engineer.
4. Complete anchor bolt assembly (studs, nuts, washers, etc.) to be provided by Contractor.
5. Bladders and replacement bladders shall be manufactured in the tank manufacturers' plant. Tanks/Vessels shall be fabricated by listed manufacturer, not contracted out.
6. Tank shell will be constructed of deep drawn carbon steel SA516 Gr 70, double sub-arc welded domes, and side shells with double welded seams. Tank shall be equipped with a food grade, heavy duty butyl rubber bladder. The precharge pressure will be located between the shell of the tank and the bladder. The end manhole shall be removable to allow inspection and maintenance of the bladder. The bladder shall be sized to conform to the inner shape of the vessel. Bladder tank shall be of the horizontal configuration.
7. Bladder tank shall be National Board approved with Pressure Relief Valve set at the tank design pressure.

F. Service Conditions

1. Tank hydraulic performance conditions and design data shall be as shown below. In the event that the manufacturer's hydraulic analysis of the system yields varying design requirements, the Engineer should be contacted.

Tank tag number:	TK-201
Tank Configuration:	Horizontal
Minimum Capacity:	16,000 gallons

Maximum Allowable Working Pressure: 150 psi

Hydrostatic Test Pressure: 225 psi

Minimum Operating Volume: ~20% of total tank volume

Bladder Material: Food Quality Butyl Rubber (IIR) With A Minimum Thickness Of 2mm, Ultimate Elongation Of 300% And Tensile Strength Of 1500 psi Minimum

Pre-charge Pressure Setting: To be provided by manufacturer

Outlet Flange Size: 24 Inch

Outlet Pressure Rating: ANSI Class 150 Per ANSI B16.5

Manhole Minimum Diameter 24"

G. Connections

1. The tank shall connect to system piping via a flanged bottom outlet.
2. The outlet shall include one (1) 1" NPT threaded port, one (1) ½" NPT threaded port, and two (2) 2" flange side connections. SUPPLIER to provide caps and/or blind flanges for connection ports not used in normal operation.
3. Contractor to provide flange isolation kits and/or flange isolation gasket kits for pipe connections points where dissimilar metals will be in contact.

H. Gas-Side Manifold and Connections

1. Provide gas-side manifold which includes connections for an air fill nozzle, pressure gauge, pressure relief valve, and level monitoring tubing.
2. Contractor to provide sign indicating the pre-charge pressure setting, as determined by manufacturer.
3. The manifold shall connect to the tank through a minimum 1" NPT threaded port. A 1" ball valve shall be provided to isolate the manifold from the tank.
4. The tank manufacturer shall provide the gas fill nozzle, pressure gauge, and pressure relief valve as described below and each shall be installed so as to be accessed and observed from ground level.
 - a. Gas Fill Nozzle: A stainless steel SA-240 nozzle shall be provided as a part of the pressure vessel for the gas pre-charge connection. Nozzle shall be connected to a ½" isolation ball valve. Nozzle shall be accessible from ground level.
 - b. Pressure Relief Valve: Install on the gas pre-charge connection to limit the fill pressure to the pressure recommended by the tank manufacturer. The pressure setting shall be field adjustable. Valve shall be of stainless steel construction.

- c. Pressure Gauges shall be furnished by the tank manufacturer.
 - 1) Pressure gauge shall be Type 1279 Duragauge as manufactured by Ashcroft Co. or approved equivalent.
 - 2) The gauge shall be selected so, under normal operating conditions, the gauge pointer will be approximately vertical and at the midpoint of the scale; and the gauge shall read pressure up to at least 10% above the design pressure. The gauge shall be hermetically-sealed and shall not be damaged by pressures up to at least 1.5 times the design pressure. Pressure gauge shall be located and oriented to facilitate easy access to and observation of the dial face from ground level. Appropriate tubing or piping shall be provided from the top of the tank to the pressure gauge.
 - 3) The pressure gauge shall be 4-1/2" dial size with black phenolic case suitable for exterior use, 1/2" NPTM lower or back mount connection. Dial shall have graduations of approximately 1% of full-scale pressure with a micrometer adjustable pointer and stainless steel movement. Gauge shall have an accuracy of 1/2% of full scale or better compliant with ANSI/ASME B40.1 Grade B.
 - 4) Pressure gauge shall be connected to a 1/2" isolation ball valve.
- 5. Ball valves shall be furnished by the tank manufacturer and shall be 3-piece full port type 316 stainless steel.
 - a. Threaded ends, 3-piece, full port, stainless steel design manufactured to MSS SP-110.b. Blow-out proof stem, two position locking vinyl grip stainless steel lever operator, compression controlled RPTFE gaskets, and adjustable multi-piece PTFE "V" style packing.
 - b. Rated for 1500 psi CWP.
 - c. Manufacturer: Acceptable ball valves are Watts Series S-FBV-1, Nibco Model T-585-S6-R-66-LL, Apollo 86A-100 Series, or approved equal.

I. Anti-Extrusion System

- 1. The bladder shall be fastened to the bottom outlet nozzle with a clamping system comprised of two half ring sections with welded stainless-steel studs. A replaceable anti-extrusion grid shall be located between the outlet flange and the clamping ring.
- 2. Bladder Clamp shall meet ANSI Class 51 Per ANSI B16.5 requirements.
- 3. Anti-Extrusion system to be provided by the surge tank SUPPLIER.

J. Valves

- 1. The tank shall be designed to function properly with the specific valves, including but not limited to plug valves and check valves, submitted by the Contractor. Acceptance of these valves shall be clearly stated in the surge tank submittal.

K. Level monitoring

1. Pressure differential transmitter

- a. Pressure differential transmitter shall be Rosemount Model 3051 digital pressure transmitter or equal.
- b. Transmitter shall be two-wire, capacitance (DP/GP) or piezoresistive (AP/GP), high performance differential/gage/absolute/level/flow pressure transmitter with HART® based fieldbus based digital communication capabilities.
- c. Pressure transmitter shall be NEC 501-5, NEMA code ICS6 and FM certified and have 4-20 mA output signal.
- d. Pressure differential transmitter shall be hard mounted on the tank via a 2" 150lbs flange. Provide 2" 150# Stainless Steel Ball Valve to isolate the differential pressure indicating transmitter (PIT).

2. Magnetic Level Gauge

- a. Tank shall be equipped with a magnetic level gauge

L. Access Manway

1. Surge tank shall be provided with an access manhole to allow inspection and maintenance of the rubber bladder. Provide permanently installed davit to remove access cover.

M. Tank Installation

1. The tank shall be installed in accordance with the manufacturer's suggested procedures. All supports, piping, valves, and related appurtenances shall be provided and installed by the Contractor at no additional cost to the Owner.

N. Field testing

The surge tank manufacturer shall verify the performance of the surge protection equipment provided, by recording surge pressures following a pump trip, furnish an updated and calibrated surge model of the installed conditions and summarize the results in a written document. During the required field visit, at least one pump trip will be required to provide field data needed for the surge model calibration. The surge tank vendor shall provide all equipment needed to record the field data during a pump trip. The pressure shall be recorded with a pressure transducer capable of recording the surge pressures at a sample rate of 100 recordings per second. Transducers and measurement software are not permanently installed. They are provided by Charlotte for testing only and are the property of Charlotte.

2.4 HEAT TRACING AND INSULATION

- A. Heat tracing for the surge tank and exposed piping shall be provided on the tank and exterior piping on the surge tank by the Contractor, in accordance with Section 26 05 50.
- B. Insulation rings shall be provided and attached to the exterior of the tank by the manufacturer to support heat tracing and insulation as specified herein.
- C. Contractor to insulate the surge tank and all exposed piping.

1. Exterior insulation and weatherproof jacketing system for piping, valves and fittings (8- inch diameter and smaller):
 - a. Flexible unicellular, closed-cell elastomeric piping insulation: ASTM C 534, Type I. AP Armaflex by Armacell Company or approved equal.
 - b. Insulation shall be mold-resistant and shall be non-wicking.
 - c. Minimum insulation thickness shall be 1-1/2 inches for 4" diameter pipe and larger, and 1 inch for smaller pipe.
 - d. Jackets for exterior insulation shall be either:
 - 1) Smooth or embossed ASTM C 921 Type I aluminum metal jacket with weather-proof construction. Minimum jacket thickness shall be 0.031 inches for exterior installations. Fastening shall use preformed "2"-lock seam with 2-inch butt strap with sealant. Bonds shall be 1/2 inch aluminum with wing seals. Fittings shall be prefabricated 0.031-inch thickness aluminum.
 - 2) For areas not susceptible to impact: ArmaTuff PLUS II self-adhesive, laminate polymeric membrane pipe covering with UV-, puncture- and tear-resistant surface by Armacell or approved equal. Membrane shall be minimum 16 mil thickness with 3-mil pressure sensitive acrylic adhesive and kraft release liner. Membrane shall serve as a vapor retarder and shall be waterproof. Laminate polymeric membrane pipe covering shall be by the same manufacturer as flexible elastomeric piping insulation.
 - e. Insulation for valves, fittings and flanges shall be mitered segments of the same product used as pipe insulation. As an alternative to insulation with separate jackets, flexible elastomeric insulation with laminated polymeric membrane covering as specified for larger piping may be used for valves, fittings and flanges.
 - f. Pipe insulation jackets shall be at least 36" long as measured along the pipe.
 - g. Special care shall be taken to make all exterior insulation jackets completely waterproof by the use of appropriate sealants at all joints, etc.
 - h. Staples, Bands, Wires, Adhesives, Cement, Tapes and Sealers: As recommended by insulation manufacturer for applications indicated.
2. Exterior insulation and weatherproof jacketing system for process/chemical tanks and large piping (8-inch nominal diameter and greater)
 - a. Flexible unicellular, closed-cell elastomeric insulation with a 16 mil thickness laminated polymeric membrane covering that is UV-, puncture- and tear-resistant—i.e. a UV protective blended polymeric top surface and a puncture-resistant blended polymeric base, around a scrim reinforced core. ArmaTuff PLUS II by Armacell Company or approved equal. Flexible elastomeric insulation shall be by the same manufacturer as flexible elastomeric piping insulation provided for smaller piping.

- b. Insulation shall be mold-resistant and shall be non-wicking.
- c. Minimum insulation thickness shall be 2 inches.
- d. The membrane shall have a 10-year warranty against breakdown due to UV radiation. Insulation layer between outer layer of duct and exterior jacket shall be a mold-resistant flexible elastomeric thermal insulation.
- e. Insulation for valves, fittings and flanges shall be mitered segments of the same product used as pipe insulation.
- f. Pipe insulation jackets shall be at least 36" long as measured along the pipe.
- g. Special care shall be taken to make all exterior insulation jackets completely waterproof by the use of appropriate sealants at all joints, etc.
- h. Staples, Bands, Wires, Adhesives, Cement, Tapes and Sealers: As recommended by insulation manufacturer for applications indicated.

2.5 PAINTING AND COATING

- A. All surface preparation, painting and coating shall comply with the requirements of Section 09 96 01 – High Performance Coating. All surface preparation, painting, and coating on the interior of the tank shall be completed at the SUPPLIER's factory. Field painting and coating shall not be acceptable for interior surfaces. Coatings on wetted components shall be ANSI/NSF 61 approved for use in potable water systems.
- B. The tank interior shall be painted with an NSF 61 epoxy coating with a uniform layer thickness of no less than 6 mils.
- C. The tank exterior shall be painted with an anti-corrosion polyurethane and shall have a uniform layer with a minimum thickness of 10 mils.

2.6 LEVEL MONITOR ASSEMBLY

- A. Provide a Manual Level Indication System for water level in the surge tank that includes the following principal components:
 - 1. Flag-style Magnetic Level Gauge (Khrone, Kobold or Engineer-approved equal) for visual monitoring of tank level. Level gauge shall be furnished with manual isolation valves at the top, at the bottom and for draining the gauge.

PART 3 - EXECUTION

3.1 DELIVERY

- A. Confirm condition of equipment with Contractor when delivered to site.
- B. Repair or return any damaged goods to the satisfaction of the ENGINEER.

3.2 INSTALLATION

- A. Confirm installation by Contractor is in accordance with the installation instructions.

3.3 OPERATOR TRAINING

- A. Provide field education for OWNER's personnel by qualified, experienced factory representative.
- B. One full 8-hour day of service from SUPPLIER's representative shall be provided per tank to approve the tank installation and advise the OWNER during startup, testing, and final adjustment of each tank. In addition to this day, one additional full 8-hour day shall be provided in a separate trip to instruct the Owner's personnel in the operation and maintenance of the tank system.

3.4 TESTING

- A. Following equipment startup, SUPPLIER shall provide onsite field testing and monitoring of the completed installation to verify performance complies with the requirements indicated herein. Testing shall be functional tests of simulated power failure with one, two, and three pumps running at full speed. Testing shall be performed in order of increasing number of pumps operating. Successive tests shall be conducted only when satisfactory results are achieved for the immediately prior test. OWNER, at their sole discretion, reserves the right to waive tests involving three operating pumps. The SUPPLIER shall prepare and submit a detailed commissioning and testing procedure for ENGINEER's review and approval.
- B. Performance monitoring shall be conducted commencing at startup of the surge tank and continuing until all required field testing has been completed and the SUPPLIER has successfully demonstrated acceptable performance of the surge tanks and associated components, to the satisfaction of the ENGINEER. In the event that the test results or surge analysis fail to establish the capability of the equipment to meet the performance conditions specified herein, the manufacturer shall upgrade the surge control equipment and systems as necessary and verify their capability to meet the specification requirements at no additional expense to the Owner.

END OF SECTION

SECTION 43 52 00 – HOISTS AND CRANES, GENERAL

PART 1 -- GENERAL

1.1 THE SUMMARY

- A. The CONTRACTOR shall FURNISH, INSTALL, AND TEST Workstation Crane System, as indicated in accordance with the Contract Documents.
- B. The CONTRACTOR shall provide the hoisting equipment, ancillary steel, and appurtenances, complete and operable, as indicated in accordance with the Contract Documents.
- C. The Free-Standing Crane System and hoist are to be designed and fabricated by a single source having total system responsibility.
- D. All equipment shall be rated for operation in a pump station environment with long periods of inactivity, and shall be in accordance with the contract drawings and specifications herewith.
- E. The Contractor shall coordinate between the vendor for all hoists and cranes and the Pre-Engineered Metal Building supplier. Final approval of layouts for the crane assembly shall be closely coordinated with the final approved Pre-Engineered Metal Building design including clearance from the building's rigid frame system to the crane assembly.
- F. The requirements of this Section apply to all hoists and cranes unless indicated otherwise.

1.2 REFERENCE SPECIFICATIONS CODES, AND STANDARDS

A. Reference Specifications

01 33 00	Submittal Procedures
01 33 17	Structural Design, Support and Anchorage
26 05 10	Electric Motors

B. Commercial Standards

AISC Specifications for the Design, Fabrication, and Erection of Structural Steel for Building

AGMA American Gear Manufacturer's Association

ASME B30.16 Overhead Hoists- Underhung

ASME HST-2M Performance Standard for Overhead Hoists

AWS D14.1 Welding of Material Handling Equipment

NFPA 70 National Electric Code

ASTM A 36 Carbon Structural Steel

CMAA A division of Material Handling Industry of America

NEMA National Electrical Manufacturer's Association

OSHA 29 CFR 1926.550 – Cranes and derricks

1.2 CONTRACTOR SUBMITTALS

- A. Furnish submittals in accordance with the requirements of Section 01 33 00 – Submittal Procedures.
- B. Shop Drawings shall include electrical requirements, weights, wheel loads, dimensions, and required clearances.
- C. Technical Manuals
 - 1. Include complete operating and maintenance instructions of the hoist and crane systems.

1.3 QUALITY ASSURANCE

- A. Inspection and Testing Requirements
 - 1. After installation, the CONTRACTOR shall inspect and test hoists and crane systems in the presence of the manufacturer's service representative, for proper operation and conformance to the indicated requirements.
- B. Acceptance Criteria and Tolerances
 - 1. The ENGINEER reserves the right to reject any equipment not conforming to the tolerances, deflections, and lateral stiffness as indicated.

1.4 MANUFACTURER'S SERVICES

- A. The CONTRACTOR shall arrange for the hoist or crane manufacturer to furnish the services of a trained, qualified representative for at least one day after the units are installed, for the purpose of inspecting the installation and instructing the OWNER's operating personnel.

1.5 DESIGN

- A. Equipment and components shall be designed and constructed in accordance with the criteria in Section 01 33 17 – Structural Design, Support and Anchorage.

PART 2 -- PRODUCTS

1.6 GENERAL

- A. Equipment of similar design shall be from a single manufacturer.
- B. The capacity of each hoist and trolley shall be permanently marked in a conspicuous manner on the equipment.
- C. The wire rope reeving shall be of the 2-part double, cross-mounted or similar appropriate type, to provide a true, vertical lift without drift, unless otherwise indicated.
- D. Hooks shall be of the safety type with a latch.

- E. The CONTRACTOR shall verify dimensions and clearances in the field prior to installation and shall be responsible for the proper fitting and operation of the equipment.
- F. Manufacturers, or Equal

- 1. **Gorbel**

1.7 BASIC MATERIALS

- A. Materials shall be new and of the best commercial grade.
- B. Where materials are not indicated, the CONTRACTOR shall have the manufacturer use the most suitable selection for the given application and environment.

1.8 PLANT FABRICATED ITEMS

- A. Fabrication, assembly, and welding shall be performed by factory-trained specialists and certified welders.

1.9 TOOLS AND SPARE PARTS

- A. Tools

- 1. The CONTRACTOR shall furnish one complete set of special wrenches or other special tools necessary for the assembly, adjustment, and dismantling of the equipment.
 - 2. The tools shall be of best quality and furnished in labeled toolboxes of suitable design.

- B. Spare Parts

- 1. Furnish spare parts as required by the hoist or crane Section.
 - 2. The parts shall be properly labeled and identified with the name and number of the equipment to which they belong.

PART 3 -- EXECUTION

1.10 INSTALLATION

- A. Hoist and crane equipment shall be installed in strict accordance with the manufacturer's printed instructions.
- B. Workmanship shall be in accordance with the referenced standards and codes.
- C. Care shall be taken that the structural integrity of beams, columns, walls, floors, and roofs will be maintained at all times.

1.11 FIELD TESTING

- A. After completion of the WORK, the CONTRACTOR shall test hoist and crane equipment in the presence of the manufacturer's field representative, who shall certify in writing that the equipment meets applicable standards and specifications.

END OF SECTION

SECTION 43 52 07 – WORKSTATION CRANES

PART 1 -- GENERAL

1.1 THE SUMMARY

- A. The CONTRACTOR shall provide a workstation crane system complete and operable, as indicated in accordance with the Contract Documents.
- B. The requirements of Section 46 01 00 – Equipment General Provisions and Section 43 52 00 – Hoists and Cranes General apply to the WORK of this Section.

PART 2 -- PRODUCTS

2.1 EQUIPMENT

A. General

- 1. The workstation crane system shall be of the low-headroom type.
- 2. The crane shall be equipped for electronic hoist for lifting.
- 3. The crane shall a manually operated trolley system.
- 4. The crane shall be mounted on standard I-beam or specially fabricated sections.
- 5. The completed crane system, except the tracks, shall be the product of one crane manufacturer regularly engaged in the manufacture of such equipment.

B. Electrical

- 1. The hoist shall be controlled from a pendant pushbutton station.
- 2. The crane shall be furnished complete with required safety devices and overload protection.
- 3. The crane power supply for hoist operation shall be from enclosed, UL-approved conductor bar systems.

C. Rails

- 1. The rails shall be standard I-beams or specially fabricated steel sections, firmly anchored to the structure in accordance with AISC design manual recommendations.
- 2. The track deflection shall not exceed 1/800 of the span or 1-1/4 inches, whichever is less.

D. Site Conditions

Equipment No	ME-100
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Location	Pump Room
Ambient Conditions	Indoors

E. The workstation crane system shall have the following capacities and dimensions:

Equipment No	ME-100
Type of Crane	Top running
Type of Bridge	Double Girder
Capacity, tons	2-ton
Maximum lift, feet	23-feet
Length of track, feet	56-feet
Length of bridge, feet	32-feet
Span between tracks, feet	32-feet
Speed Control	Single Speed
Lifting Speed, fpm	15-fpm
Trolley Speed, fpm	65-fpm
Bridge Speed, fpm	65-fpm
Hoist Motor, hp	3
Trolley Motor, hp	Not Applicable, manual
Bridge Motor, hp	Not Applicable, manual
Power Supply, V-ph-Hz	480-3-60

2.2 FABRICATION

A. Hook and Wire Rope

1. The lifting hook shall be constructed of drop-forged, heat-treated steel with a 360-degree swivel on a shielded roller thrust bearing with a safety spring latch.
2. The wire ropes shall be improved plow steel with steel center, complete with swaged fittings.

B. Hoist and Drive

1. The hoisting drum shall be a large diameter, deep-grooved and flanged drum with at least 2 full turns of rope to remain on the drum at the lowest hook position, and shall be provided with heavy-duty, pre-lubricated sealed bearings.
2. The drum shall be driven by a helical gear reducer with an external spur drum gear enclosed in an oil-tight housing.
3. The housing motor shall be a standard, 30-minute duty-motor, 1750 rpm, with a suitable NEMA type shaft extension.
4. The hoisting mechanism shall be provided with a DC magnet-actuated disc motor brake with hook drift.
5. The motor shall be rated with minimum of 150 percent of full load torque, with a gravity type upper and lower hook limit switch, and an overload cut-off switch to interrupt the raising circuit.

C. Trolley Assembly

1. The trolley assembly shall be of the top-running type, framed by a structural shape welded into a stable assembly for proper wheel and bearing alignment.
2. The trolley assembly shall be supported by trolley wheels of tread surfaces hardened to 375 to 425 Brinell.
3. The tread shall be tapered in order to provide a suitable running alignment for the trolley.
4. Each wheel shall be supported on tapered roller bearings suitable to take radial and thrust loads, as required.
5. The wheel mounting shall be designed such that the axles and wheels can be removed without disturbing other truck elements from their alignment.
6. The wheel tread shall be smooth, true, and uniform within 0.010-inch tread diameter on every wheel.

D. Trolley Drive

1. The trolley shall be manually operated.

E. Crane Bridge Assembly

1. The crane bridge assembly shall be a single beam over-riding or top-running double beam, electrically driven, and of the center-drive type.
2. The bridge beam shall be designed in accordance with the latest specifications of the Crane Manufacturers Association of America, and shall be fabricated of standard structural shapes per AISC Specifications.
3. At full load, the beam shall be designed to limit the deflection to 1/600 of the span, but not to exceed 1-1/4 inch maximum deflection.

4. An ASCE rail shall be provided on top of the beam, securely fastened in place in order to maintain center distance.
5. Provisions shall be made to prevent the creeping of bridge rails by means of positive stops at the ends of the rails.
6. The crane shall be reinforced with an outrigger in order to provide squareness with the end truck, and an adequate lateral stiffness with a minimum lateral moment of inertia of $1/20$ that of the vertical beam moment of inertia.
7. The outrigger shall furnish support for the squaring shaft, the crane drive motor, and the gear reducer assembly.

F. End Trucks

1. The end trucks shall be traversed by a stable assembly of structural shapes welded together in order to provide proper wheel and bearing alignment.
2. The end truck wheel base shall be a minimum of $1/7$ of the crane span.
3. One wheel of each end truck shall be geared and meshed with the pinion mounted on the crane squaring shaft.
4. The crane and trucks shall contain diaphragm members welded to the truck frames on order to maintain alignment and to distribute truck loads on the inner and outer truck members.
5. The truck shall be designed such that, in the case of a wheel axle or wheel failure, the drop of the load will be limited to one inch.
6. The end trucks shall be fastened to the bridge beams with bolts in order to ensure assembly alignment.

G. Crane Wheels

1. Crane wheels shall have tread surfaces hardened to 375 to 425 Brinell.
2. The treads shall be tapered in order to provide suitable running alignment for the crane.
3. Each wheel shall be supported on tapered roller bearings mounted on stationary axles, suitable to take radial and thrust loads as required.
4. The wheels shall be lubricated at the factory with a sodium-based grease, and provided with a suitable reservoir of lubricant in order to eliminate the need for field lubrication.
5. Wheel axles shall be provided with mounting nuts for bearing adjustment.
6. The wheel mounting shall be designed such that axles and wheels can be removed without disturbing other truck elements from their alignment.
7. The wheel treads shall be smooth, true, and uniform within 0.01-inch tread diameter on every wheel.

H. Crane Drive

1. The crane shall be manually operated.

I. Bearing Life

1. Bearings in the crane wheels, supporting the drive shafts, and in the gear reduction shafts shall be designed for a minimum 5,000-hour L-10 bearing life.

J. Gearing

1. Gears shall be cut from solid blanks with a 20-degree pressure angle involute shape for high strength, and shall comply with AGMA specifications for load ratings.
2. Gears operating at higher than 20 fpm pitch line speed shall be fully enclosed in oil-tight housings and lubricated by the splash principle.
3. Gear teeth shall have ductile cores and shall be surface-hardened to RC40, minimum.
4. The gear shall provide for a minimum service of 4,000 hours, compounded for intermittent operations corresponding to 5 years minimum industrial use.

K. Bridge Stops

1. The bridge shall be provided with bumpers capable of stopping the crane (not including the lifted load) at a rate of deceleration not to exceed 3 fps when traveling in either direction at 20 percent of rated speed.
2. The bumpers shall have sufficient energy-absorbing capacity to stop the crane when traveling at a speed of at least 40 percent of the rated load speed.
3. The bridge trucks shall be equipped with sweeps which extend below the top of the rail and project in front of the crane wheel.

L. Runway Beams and Rails

1. The runway beams and rails shall be as indicated.
2. The rails shall be of an ASCE type and securely fastened into the runway beams.
3. The runway beams shall be designed from an ASTM A 36 structural steel shapes, and shall have a maximum deflection of 1/800 of the span.
4. The beams shall be equipped with stops on both ends capable of withstanding the impact of the fully loaded crane at 50 percent of its rated speed, and shall be field-adjustable.
5. Necessary column supports and clamps, hanger rods, bolts, and fittings shall be provided.

M. Controls shall be in accordance with the requirements of Section 40 61 96 – Process Control Descriptions

2.3 ELECTRICAL CONTROLS

- A. Electrical controls shall be multiple-speed.
- B. Limit Switches
 - 1. Geared Limit Switches
 - a. The switches shall be of the heavy-duty quick-break, double-pole, double-throw type, conforming to NEMA ICS 2.
 - b. The geared limit switch interruption of a motion in one direction shall not prevent the opposite motion.
 - c. Geared limit switches shall reset automatically.
 - 2. Proximity and mechanical arm type limit switches shall be oil-tight with and provided with cover gaskets.
 - 3. The limit switch enclosures shall be rated NEMA 250, Type 4X.
 - 4. Except as approved by ENGINEER, the limit switches shall be provided with a minimum of one spare, isolated, normally open and normally closed set of contacts.
 - 5. Where possible, limit switches shall be provided with a fixed number of contacts in order to simplify re-ordering and to minimize the OWNER's spare parts stock.

2.4 CONDUCTORS AND WIRING

- A. The runway shall be provided with enclosed conductor base electrification, adequately supported.
- B. The trolley shall have rigid truck festoon type electrification.
- C. Other wiring of the crane shall be enclosed in rigid or flexible conduit, and shall be in accordance with the National Electrical Code and comply with Fire Underwriters specifications.
- D. When the crane is shipped, the wiring shall terminate in approved terminal boxes and the wire end shall be provided with permanent marking tags.
- E. Shop Assembly Tests (No-Load)
 - 1. Prior to shop assembly tests, submit a detailed Shop Inspection and Test Plan to the ENGINEER to demonstrate the fulfillment of the indicated requirements.
 - 2. The bridge crane and appurtenant items shall be completely assembled, tested, and inspected in the shop, unless otherwise approved, in order to demonstrate that the equipment and accessories are fully functional and meet the indicated performance requirements.
 - 3. Adjoining components shall be fitted, doweled, and bolted together in order to ensure proper fit during field erection and assembly.

4. Assembled components shall be shop-welded in their final positions as much as shipping limitations and field installation conditions will permit.
5. Inspections
 - a. Shop-assembled components shall be inspected for accurate fit, correctness of dimensions, accuracy of alignment, ease of movement, and proper painting.
 - b. Any errors, misalignments, and quality deficiencies that are discovered shall be corrected.
6. Perform mechanical, electrical, and functional shop tests on the crane equipment.
7. The crane shall be completely wired to energize the various motors, brakes, and limit switches through electrical panels using the crane's own controls.
8. The hoist and drive machinery shall be checked for correct direction of rotation, and quiet and uniform engagement of the gearing.
9. The trolley shall be placed on the bridge and traveled the entire length in order to verify adequate clearances and to demonstrate proper tracking.
10. Operating devices, brakes, switches, and control devices, and the like, shall be inspected and tested in order to ensure proper operation.
11. The satisfactory operation and proper speeds of hoist and drives shall be verified.
12. No equipment shall be shipped to the Site until it has been inspected and released for shipment.
13. Match-Marking
 - a. Before disassembling, and after installation of dowels and fitted bolts between bolted subassemblies, the parts shall be clearly match-marked.
 - b. Match-mark diagrams shall be prepared for field erection and submitted for review.
14. Shop Test Report
 - a. Prepare a complete test report showing in detail the results of shop tests, including dimensional checks.
 - b. The test report shall include a detailed tabulation showing design values, values of measurements, and adjustments recorded during the tests.
 - c. Copies of shop inspection records shall be furnished to the ENGINEER.

PART 3 -- EXECUTION

3.1 GENERAL REQUIREMENTS

- A. The bridge crane equipment shall be installed in strict conformance with the manufacturer's published or written instructions.

- B. The cranes shall be factory assembled and given a no-load test.
- C. Major components of the system shall be marked at the factory to assure prompt and correct field identification.
- D. After completion of the WORK, the CONTRACTOR shall test the hoist and crane equipment in the presence of the manufacturer's field representative, who shall certify in writing that the testing performed shall satisfy State of Ohio and other applicable codes and specifications in order to certify each crane for operation.

3.2 Field Testing

- A. Personnel and equipment necessary to conduct the testing of the installed equipment shall be furnished by CONTRACTOR.
- B. The equipment shall include at least test weights, rigging, safety gear, electrical meters, measuring devices and other equipment required during the course of testing.
- C. Equipment shall be checked, operated, adjusted, and tested in accordance with the requirements herein and the manufacturer's written instructions and procedures as approved by the ENGINEER.
- D. Suitable checks shall be made for physical connections, clearances, wiring, controls, limit switches, and other devices as required.
- E. The tests shall be conducted in the presence of ENGINEER and OWNER, for the purpose of demonstrating compliance with the indicated requirements.
- F. Equipment shall have operated and shall have had necessary corrections and adjustments made before testing in the presence of the ENGINEER and OWNER.

G. No-Load Tests

1. Hoist

- a. Each load hook shall be raised and lowered through the full range of normal travel at the rated speed and other speeds of the crane.
- b. The load hook shall be stopped below the geared limit switch upper setting.
- c. Proper set-point and operation of upper and lower limit switches shall be verified at a slow speed.
- d. The test shall be repeated a minimum of 3 times in order to demonstrate proper operation, followed by operation at a high speed.
- e. Brake action shall be tested in each direction.
- f. Dynamic and holding brake action shall be verified.
- g. Load float shall be verified in order to ensure that holding brakes set and release properly.

2. Trolley Travel

- a. The trolley shall be operated the full distance of the rails, exercising drive speed controls in each direction.
 - b. Brake operation shall be verified in each direction.
 - c. Proper operation (interrupt power, automatic reset) of the trolley limit switches at both limits of trolley motion shall be tested in slow speed.
 - d. The trolley bumpers shall contact the trolley stops located on the longitudinal girders in slow speed.
 - e. The trolley shall be run in each direction of travel for at least 4 complete cycles of trolley travel in order to disclose any noisy operation and misalignments at the bearings, gearing, or motors.
3. Bridge Travel
- a. The bridge shall be operated the full distance of its runway, exercising the drive speed controls in each direction.
 - b. Brake operation shall be verified in each direction.
 - c. Proper operation (interrupt power, automatic reset) of the bridge limit switches at both limits of bridge motion shall be tested in slow speed.
4. Hoist Loss of Power No-Load Test
- a. Raise each hook to a safe working level above the deck to perform the no-load test.
 - b. While slowly lowering each hook, the main power source shall be disconnected verifying that the hook stops lowering and that holding brakes are set.
5. Travel Loss of Power No-Load Test
- a. With the hook raised to clear obstructions and one traversing motion (trolley and gantry) in slow speed, the main power source shall be disconnected in order to verify that the traversing motion stops and that the parking brake sets.
 - b. Repeat the test for each traversing motion of each crane.
 - c. Repeat the loss-of-power test at full speed in order to verify that the brakes operate properly within an acceptable stopping distance.

H. Load Tests

- 1. Load tests shall be carried out using a test load not less than 100 percent of the rated load, and not greater than 125 percent of the rated load.

I. Hoist Static Load Test

- 1. The holding brake and hoisting components shall be tested by raising the test load approximately one foot above the deck.

2. The load shall be held for 10 minutes.
3. Any lowering of the load during this test indicates a malfunction of the brake or lowering components.

J. Hoist Dynamic Load Test

1. The test load shall be raised and lowered over the full travel with the hook, accelerating through the full speed range.
2. The hook shall be stopped, the load floated, then the holding brake allowed to set with the load suspended.
3. The hook shall be restarted in both RAISE and LOWER directions, to demonstrate floating of the load before holding brake release on start-of-motion, and floating of the load before holding brake set.
4. Load memory shall also be demonstrated for rapid restart of the hoist after the holding brake has been set.

K. Hoist Loss of Power Test

1. After raising the test load to approximately 8 feet above the deck, begin slowly lowering the test load and trip off the main power source in order to verify that the test load does not lower and that the brake set.

L. Travel Dynamic Load Test

1. With the test load on the hook, one traversing motion (trolley or bridge travel) shall be operated for the full length of its runway in both directions.
2. Proper function of drive speed control points and brake action without mechanical binding shall be verified, including load swing control and the ability to do a bumpless restart of the drive into a load that is already moving.
3. Repeat the test for each traversing motion of crane.

M. Travel Loss-of-Power Test

1. With the load test raised to clear obstructions and one traversing motion (trolley and gantry) in slow speed, the main power source shall be disconnected in order to verify that the traversing motion stops and that the parking brake sets.
2. Repeat the test for each traversing motion of each crane.
3. Repeat the loss-of-power test at full speed in order to verify that the brakes operate properly within an acceptable stopping distance.

END OF SECTION

SECTION 46 10 00 – EQUIPMENT GENERAL PROVISIONS

PART 1 -- GENERAL

1.01 SUMMARY

- A. The provisions of this Section shall apply to all equipment throughout the Contract except where otherwise indicated. The Contractor shall provide equipment and appurtenant Work, complete and operable, in accordance with the Contract Documents.
- B. The equipment Arrangement: Unless specifically indicated otherwise, the arrangement of equipment indicated is based upon information available from manufacturers at the time of design and it is not intended to show exact dimensions particular to a specific manufacturer. Some aspects of the Drawings are diagrammatic, and some features of the illustrated equipment arrangement may require revision by the Contractor to meet the actual equipment requirements proposed by the Contractor. Structural supports, foundations, piping and valve connections, and electrical and instrumentation connections indicated may have to be altered by the Contractor to accommodate the equipment provided. No additional payment will be made to the Contractor for such revisions and alterations. Substantiating calculations and drawings shall be submitted prior to beginning the fabrication of equipment.
- C. Unit Responsibility:
 - 1. The Contractor shall furnish, coordinate, assemble, install, and test the system as an operating unit. Unless otherwise specified:
 - 2. The Contractor shall furnish, coordinate equipment selection with the manufacturer of the driven equipment to insure compatibility. The manufacturer shall assure selected components of the system are checked for compatibility, ease of construction, and efficient operation and maintenance. The manufacturer shall ensure coordination of design of all system components such that all equipment furnished under the specifications for the equipment system, including equipment specified elsewhere but referenced in the specification, is compatible and operates properly to achieve the performance requirements specified. Agents, representatives, or other entities who are not a direct component of the manufacturing corporation will not be acceptable as a substitute for the manufacturer's corporation in meeting this requirement.
 - 3. This requirement for unit responsibility shall in no way relieve the Contractor of responsibility for meeting the overall performance of equipment as specified in the Contract Provisions.
 - 4. The Contractor shall assure that all equipment systems provided for the project are products for which unit responsibility has been coordinated by the responsible party.
 - 5. Where the specification requires a Certificate of Unit Responsibility, submit a statement signed by an officer of the manufacturer's corporation, and certified by the Contractor that the equipment have been designed, selected and coordinated are compatible with the overall integrated system as specified.
 - 6. No other submittal material will be processed until a Certificate of Unit Responsibility has been received and has been found to be satisfactory.

D. Single Manufacturer: Where two or more pieces of equipment of the same type or same size are required, the equipment shall be produced by the same Manufacturer.

E. Protection During Shipment and Storage

1. General: Unless otherwise specified in the specific Section for the equipment, this paragraph applies.
2. Shipping:
 - a. Equipment: Ship in sealed, weather-tight enclosed containers with silica gel desiccants to protect equipment from moisture and corrosion during shipment. Equipment shall be properly and protected against from being damaged or stresses during transport to the job site.
 - b. Bearing housings: Protect antifriction bearings from being damaged in transit due to moisture and contaminants. Shafts locked to equipment housing to prevent bearing damage during shipment.
3. Damage: Correct to conform to the Contract requirements before the assembly is incorporated into the work.
4. Factory applied coatings: Each item of equipment shall be shipped to the site of the work with the manufacturer's shop applied prime coating.
5. Special monitoring: For the equipment listed below, a recording accelerometer, designed to record the magnitude of sudden impacts in 3 directions (X, Y, Z) on continuous strip charts with both time and "g" force scales, shall be shipped with, and fixed to each separately packed assembly or its packing crate. The units shall be shipped with a backup accelerometer and with new batteries. Upon arrival of each shipment, immediately notify the Project Representative; the accelerometer: shall be removed in the presence of representatives of the Project Representative and the Contractor. If the magnitude of the maximum acceleration exceeds 3.0 g, the assembly and any subassembly shall be dismantled and inspected for damage.
6. The following list of equipment shall be monitored during shipment:
 - a. All electric motors and pumps 500 hp and larger or pump with a rated capacity of 10,000 gpm or larger.
 - b. All blowers, compressors with motors 500 hp and larger.

1.02 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

A. Reference Specifications

01 33 00	Submittal Procedures
01 33 17	Structural Design Support and Anchorage
01 75 00	Equipment Testing and Plant Startup
01 79 00	Owner Staff Training
03 60 00	Grouting
05 50 00	Metal Fabrications

09 96 00	High-Performance Coatings
40 05 01	Piping, General
40 05 07	Hangers and Supports for Process Piping

B. Reference Standards

American Bearing Manufacturers Association (ABMA)	
American Gear Manufacturers Association (AGMA)	
American National Standards Institute (ANSI)	
ANSI B46.1	Surface Texture (Surface Roughness, Waviness, and Lay)
ANSI S12.6	Method for the Measurement of the Real-Ear Attenuation of Hearing Protectors
American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE)	
American Society of Mechanical Engineers (ASME)	
ASME B16.1	Cast Iron Pipe Flanges and Flanged Fittings, Class 25, 125, 250, and 800
ASME B16.5	Pipe Flanges and Flanged Fittings, Steel, Nickel Alloy, and other Special Alloys
ASME B46.1	Surface Texture
ASME B1.20.1	General Purpose Pipe Threads (Inch)
ASME B31.1	Power Piping
ASME B31.3	Process Piping
American Water Works Association (AWWA)	
AWWA M11	Steel Pipe – A Guide for Design and Installation
AWWA C206	Field Welding of Steel Water Piping
AWWA C207	Steel Pipe Flanges for Waterworks Service – Sizes 4 In. Through 144 In.
AWWA D100	Welded Steel Tanks for Water Storage
American Welding Society (AWS)	
American Society for Testing and Materials (ASTM)	
ASTM A 48	Gray Iron Castings
ASTM A 108	Steel Bars, Carbon, Cold-Finished, Standard Quality
Federal Specifications (FS)	
General Industry Safety Orders (GISO)	
Hydraulic Institute (HI)	
Mechanical Power Transmission Association (MPTA)	
National Electrical Manufacturers Association (NEMA)	
National Fire Protection Association (NFPA)	
NFPA 820 Standard for Protection in Wastewater Treatment and Collection Facilities	
NSF International (NSF)	
NSF/ANSI 61	Drinking Water System Components – Health Effects

Occupational Safety and Health Administration (OSHA).
Underwriters Laboratories (UL)
Rubber Manufacturers Association (RMA)

1.03 ACTION SUBMITTALS / INFORMATIONAL SUBMITTALS

A. Product Data

1. Submit product data consisting of manufacturer's printed data sheet or catalog cuts illustrating product information required to demonstrate that the equipment meet project section subject to review by the ENGINEER.

B. Shop Drawings Submittals

1. Furnish submittals in accordance with Section 01 33 00– Submittal Procedures.
2. Shop Drawings: Furnish complete drawings and technical information for equipment, piping, valves, and controls. Where indicated or required by the Engineer, Shop Drawings shall include clear, concise calculations showing equipment anchorage forces and the capacities of the anchorage elements proposed by the Contractor.
3. Spare Parts List: The Contractor shall obtain from the manufacturer and submit as part of Shop Drawings a list of specified and recommended spare parts for each piece of equipment. Contractor shall also furnish the name, address, and telephone number of the nearest distributor for each piece of equipment.

1.04 QUALITY ASSURANCE

- A. Costs: Responsibility shall be by the Contractor's for performing and paying the costs of inspection, startup, testing, adjustment, and instruction services performed by factory representatives. The Owner will pay for costs of power and water. If available, the Owner's operating personnel will provide assistance in the field testing.
- B. Inspection: The Contractor shall inform the local authorities, such as building and plumbing inspectors, fire marshal, OSHA inspectors, and others, to witness required tests for piping, plumbing, fire protection systems, pressure vessels, safety systems, cranes, and related items to obtain required permits and certificates, and shall pay inspection fees.
- C. Quality and Tolerances: Tolerances and clearances shall be as shown on the Shop Drawings and shall be closely adhered to.
- D. Machine Work shall be of high-grade workmanship and finish, with due consideration to the special nature or function of the parts. Members or machine parts without machined or milled ends and which are to be framed to other steel parts of the structure may have a variation in the detailed length of not greater than 1/16-inch for members 30-feet or less in length, and not greater than 1/8-inch for members over 30-feet in length.

- E. Castings shall be homogeneous and free from non-metallic inclusions and defects. Surfaces of castings which are not machined shall be cleaned to remove foundry irregularities. Casting defects not exceeding 12.5 percent of the total thickness and where defects will not affect the strength and serviceability of the casting may be repaired by approved welding procedures. The Engineer shall be notified of larger defects. No repair welding of such defects shall be carried out without the Engineer's written approval. If the removal of metal for repair reduces the stress resisting cross-section of the casting by more than 25 percent or to such an extent that the computed stress in the remaining metal exceeds the allowable stress, then the casting may be rejected. Costs of casting new material shall be the Contractor's responsibility as part of the Work.
- F. Materials shall meet the physical, chemical, metallurgical and mechanical properties in accordance with the reference standards. All materials or products shall be new and from a Manufacturer specializing in the manufacture of the product. All materials shall be high-grade, standard commercial quality, free from all defects and imperfection, and shall be recommended by the Manufacturer for the intended application.
- G. Machine Finish: The type of finish shall be the most suitable for the application as recommended by the equipment manufacturer in micro-inches in accordance with ANSI B46.1 Surface Texture (Roughness, Waviness, Lay). In the absence of manufacturer's recommendations, the following surface finishes shall be used:
1. Surface roughness not greater than 63 micro-inches shall be required for surfaces in sliding contact.
 2. Surface roughness not greater than 250 micro-inches shall be required for surfaces in contact where a tight joint is not required.
 3. Rough finish not greater than 500 micro-inches shall be required for other machined surfaces.
 4. Contact surfaces of shafts and stems which pass through stuffing boxes and contact surfaces of bearings shall be finished to not greater than 32 micro-inches.
- H. Manufacturer's Experience: Equipment manufacturer shall have a record of proven experience of at least 5 years of successful, trouble-free operation in similar applications, type, model and size equal or larger than the equipment specified in this Contract. Where indicated in each individual equipment specifications, the Contractor shall submit this experience record to the Engineer for approval.
- I. Certificates
1. Submit all equipment certificates to demonstrate that the equipment met provisions of specification in performance, materials, function, controls and operation as specified in each specific equipment specification sections.
- J. Manufacturer's Instructions
1. Submit equipment manufacturer's instruction documenting packaging, shipping and delivery, storage, installation, startup, and operation and maintenance.
- K. Source Quality Control Submittals

1. Submit source quality control procedures for foundry, machining, welding assembly and field installation in accordance with ISO 9001 Quality Procedures. Include non-destructive testing procedures as required to demonstrate and ensure quality of finished product. Equipment manufacturer shall be responsible of enforcing quality assurance procedures to producers for sub-manufactured parts.

L. Field Quality Control Submittals

1. Submit field quality control procedures for equipment from installation, startup and commissioning. Quality control procedure shall clearly describe specification performance requirement, function and controls, checkout steps, sign-off by Inspector. Submit test results and certificate signed by the equipment manufacturer representative, contractor and witnessed by the field engineer.

1.08 MAINTENANCE MATERIAL SUBMITTAL

A. Spare Parts

1. Submit list of spare parts as specified in each equipment specification Section.
2. Submit list of spare parts recommended by the equipment manufacturer in addition to what was already required as part of the contract.

PART 2 -- PRODUCTS

2.01 GENERAL REQUIREMENTS

- A. Noise Level: When the equipment is in operation, no equipment shall exceed the following OSHA permissible noise exposure levels per day; 105 dBA for one hour, 100 dBA for two hours or 90 dBA for eight hours.
- B. High Noise Level Location: The Contractor shall provide one personal hearing protection station at each location defined as follows:
 1. Outdoor Location: Any single equipment item or any group of equipment items that produce noise exceeding OSHA noise permissible level for a 2-hour exposure. Where such equipment is separated by a distance of more than 20-feet, measured between edges of footings, the area for each group of equipment shall be provided with a separate hearing protection station.
 2. Indoor Location
 - a. Any single equipment item or any group of equipment items located within a single room not normally occupied, that produces noise exceeding OSHA noise permissible level for a 2-hour exposure.
 - b. Any single equipment item or any group of equipment items located within a single room normally occupied by workers that produces noise exceeding OSHA noise permissible level for an 8-hour exposure.

- C. Personal Hearing Protection: The Contractor shall furnish 3 pairs of high attenuation hearing protectors in the original unopened packaging. The ear protectors shall be capable of meeting the requirements of ANSI S12.6 and shall produce a noise level reduction of 25 dBA at a frequency of 500 Hz. The hearing protectors shall have fluid filled ear cushions and an adjustable, padded headband. The protectors shall be stored in a weatherproof, labeled, steel cabinet, provided at an approved location near the noise producing equipment.

D. Mechanical Service Factors

	Mechanical Service Factors	
	Electric Motor	Internal Combustion Engine
Uniform	1.25	1.50
Moderate Shock	1.50	1.75
Heavy Shock	2.00	2.25

- E. For thermal rating adjustments such as start frequency, ambient temperature, and hourly duty cycle factor, ventilation factor, and fan factor, refer to the manufacturer sizing information.
- F. Where load classifications are not indicated, the equipment manufacturer's recommendations for service factors shall be utilized.
- G. Welding: Unless otherwise indicated, welding shall conform to the following:
1. Welding shall be by the metal-arc method or gas-shielded arc method as described in the American Welding Society's "Welding Handbook" as supplemented by other pertinent standards of the AWS. Qualification of welders shall be in accordance with the AWS Standards.
 2. Weld reinforcement shall be as specified by the AWS code. Upon completion of welding, weld splatter, flux, slag, and burrs left by attachments shall be removed. Welds shall be repaired to produce a smooth and acceptable appearance with uniform weld contours and dimensions. Sharp corners of material that are to be painted or coated shall be ground to a minimum of 1/32-inch on the flat.
 3. Composite fabricated steel assemblies that are to be erected or installed inside a hydraulic structure, including any fixed or movable structural components of mechanical equipment, shall have continuous seal welds to prevent corrosion of hard-to-coat metallic surfaces.
 4. Welded steel tanks: Latest revision of AWWA D100.
 5. Welded steel piping: Latest revision of AWWA C206.
- H. Protective Coating: Equipment shall be painted or coated in accordance with Section 09 96 00– High-Performance Coatings, unless otherwise indicated. Non-ferrous metal and corrosion-resisting steel surfaces shall be coated with grease or lubricating oil. Coated surfaces shall be protected from abrasion or other damage during handling, testing, storing, assembly, and shipping.

- I. Potable Water Contact: Materials immersed in or exposed to potable water shall be made of materials or coated compliant with NSF/ANSI 61. Bronze alloy materials in contact with potable water shall be constructed of zero-lead materials or materials whose lead content do not exceed the weighted average criteria as required by the Lead Reduction Act. Equipment manufacturer shall submit to the Engineer a certification of compliance with the requirement of NSF Standard 61 and the Lead Reduction Act.
- J. Protection of Equipment: Machined and coated surfaces shall be protected by rust inhibitor material prior to shipment. Equipment shall be boxed, crated, or otherwise protected from damage and moisture during shipment, handling, and storage. Equipment shall be protected from exposure to corrosive fumes and shall be kept thoroughly dry. Equipment with anti-friction bearings or sleeve bearings shall be protected from being damaged due to jarring motion during shipment. Pumps, motors, drives, electrical equipment, and other equipment having anti-friction or sleeve bearings shall be stored in weathertight storage facilities prior to installation. For extended storage periods, plastic equipment wrappers should be avoided to prevent accumulation of condensate in gears and bearings. In addition, motor space heaters shall be energized, and shafts shall be rotated per manufacturer's recommendation. Equipment delivered to the Site with rust or corroded parts shall be rejected. If equipment develops defects during storage, it shall be disassembled, cleaned, recoated, or otherwise corrected to restore it to original condition.
- K. Identification of Equipment Items
 - 1. At the time of shipping, each item of equipment shall have a legible identifying mark corresponding to the equipment number in the Contract Documents for the particular item.
 - 2. After installation, each item of equipment shall be given permanent identification.
 - a. Pumps, compressors, and blowers of 150 horsepower or less shall receive acrylic plastic or stainless steel plate nametags.
 - b. Pumps, compressors, and blowers larger than 150 horsepower shall receive stainless steel plate nametags.
- L. Vibration Isolators: Air compressors, blowers, engines, inline fans shall be provided with restrained spring-type vibration isolators or pads per manufacturer's written recommendations. Vibration isolations shall be provided with seismic restraint.
- M. Equipment Maximum Allowable Vibration Level: Unless otherwise indicated, maximum allowable vibration level shall be in accordance with the acceptance criteria recommended by the reference Standard for that particular type of equipment
- N. Shop Fabrication: Shop fabrication shall be performed in accordance with the Contract Documents and the Shop Drawings.
- O. Controls: Equipment and system controls shall be in accordance with Division 40 - Instrumentation.

2.02 EQUIPMENT SUPPORTS AND FOUNDATIONS

- A. Equipment Supports: Equipment components and supports, anchors, and seismic restrainers shall be adequately designed for static, dynamic, wind, and seismic loads. The design horizontal seismic force shall be the greatest of the following design criteria:
1. Design Criteria noted in Section 01 33 17– Structural Design Support and Anchorage.
- B. Submit design calculations for equipment supports, anchors, and seismic restrainers signed and sealed by an engineer registered in the State wherein the project is to be built. Calculations shall account for forces and distribution of forces on supporting structures resulting from normal operation, normal operation plus seismic loadings, and normal operation plus wind loadings in accordance with Section 01 33 17 – Structural Design Support and Anchorage.
1. Wall-mounted equipment weighing more than 250 pounds, or which is within 18-inches above the floor shall be provided with fabricated steel supports. Pedestals shall be of welded steel. If the supported equipment is a panel or cabinet or is enclosed with removable sides, the pedestal shall match the supported equipment in appearance and dimensions.
 2. Seismic requirements: Freestanding and wall-hung equipment shall be anchored in place by methods that satisfy Section 01 33 17– Structural Design Support and Anchorage. Calculations shall be performed and signed and stamped for equipment weighing more than 400 pounds. Calculations shall analyze lateral and overturning forces and shall include a factor of safety against overturning equal to 1.5. Calculations shall include the distribution of forces imposed on the supporting structure and anchors, verifying that each anchor can develop the required resistance forces.
 3. Wind requirements: Exterior freestanding equipment shall be anchored in place by methods that satisfy Section 01 33 17– Structural Design Support and Anchorage. Calculations shall be performed and signed and stamped, analyzing lateral and overturning forces and shall include a factor of safety against overturning equal to 1.5. Calculations shall include the distribution of forces imposed on the supporting structure and anchors, verifying that each anchor can develop the required resistance forces.
 4. Anchors: Anchor bolts shall be in accordance with Section 05 50 00– Metal Fabrications. Contractor shall determine the size, type, capacity, location, and other placement requirements of anchorage elements. Anchoring methods and leveling criteria in the manufacturer's literature shall be followed. Submit methods and criteria with the Shop Drawings.
 5. Equipment Grout: Mechanical equipment installed on top of concrete foundations or bases shall be provided with non-shrink concrete or epoxy grout as indicated and as specified in Section 03 60 00- Grouting. Grout shall be applied between the base plate and the concrete foundation or base in accordance with the grout manufacturer's recommendation. Grout shall be free of void space.

2.03 COUPLINGS

- A. Mechanical couplings shall be provided between the driver and the driven equipment. Flexible couplings shall be provided between the driver and the driven equipment to accommodate slight angular misalignment, parallel misalignment, end float, and to cushion shock loads. Unless otherwise indicated or recommended by the equipment manufacturer, coupling type shall be furnished with the respective equipment as follows:

Equipment Type	Coupling Type
Horizontal and end suction pumps	Gear or flexible spring
Vertical turbine pumps	3-piece spacer for solid shaft or double nut for hollow shaft
Vertical nonclog pumps, close coupled	Flexible disc pack
Screw pumps	Flexible spring, gear coupling, fluid coupling
Vertical nonclog pumps with extended shaft	Flexible disc pack
Belt conveyors	Gear coupling for fractional to 7.5 horsepower, Silicone filled fluid coupling for 10 hp and larger
Sludge collector	Gear coupling or jaw clutch
Engine driven pumps	Flexible disc pack or elastomeric flexible type
Single stage centrifugal blowers	Flexible disc pack
Air compressors	Gear or flexible disc pack

- B. Each coupling size shall be determined based on the rated horsepower of the motor, speed of the shaft, and the load classification service factor. The Contractor shall have the equipment manufacturer select or recommend the size and type of coupling required to suit each specific application.
- C. Differential Settlement: Where differential settlement between the driver and the driven equipment may occur, 2 sets of flexible disc pack couplings or as recommended by equipment manufacturer shall be provided.
- D. Taper-Lock or equal bushings may be used to provide for easy installation and removal of shafts of various diameters.

2.04 SHAFTING

- A. General: Equipment manufacturer shall be responsible for designing and manufacturing shafting to carry all loads applied to the shaft. Shafting shall be continuous between bearings and shall be sized to transmit the power required. Keyways shall be accurately cut in line. Shafting shall not be turned down at the ends to accommodate bearings or sprockets whose bore is less than the diameter of the shaft. Shafts shall rotate in the end bearings and shall be turned and polished, straight, and true.
- B. Design Criteria: Shafts shall be designed to carry the steady state and transient loads suitable for unlimited number of load applications.

C. Materials: Shafting materials shall be compatible with the type of service and load transmitted. Environmental elements such as corrosive gases, moisture, and fluids shall be taken into consideration. Materials shall be as indicated unless furnished as part of an equipment assembly.

1. Low carbon cold-rolled steel shafting shall conform to ASTM A 108, Grade 1018.
2. Medium carbon cold-rolled shafting shall conform to ASTM A 108, Grade 1045.
3. Other grades of carbon steel alloys shall be suitable for service and load.
4. Corrosion-resistant shafting shall be stainless steel or Monel, whichever is most suitable for the intended service.

2.05 GEARS AND GEAR DRIVES

- A. Unless otherwise indicated, gears shall be of the spur, helical, or spiral-bevel type, designed and manufactured in accordance with AGMA Standards, with a service factor suitable for load class, mechanical service and thermal rating adjustment, a minimum L-10 bearing life of 60,000 hours, and a minimum efficiency of 94 percent. Peak torque, starting torque, and shaft overhung load shall be checked when selecting the gear reducer. Worm gears shall not be used unless specifically approved by the Engineer.
- B. Gear speed reducers or increasers shall be of the enclosed type, oil- or grease-lubricated and fully sealed, with a breather with humidity control filter to allow air to escape but keep moisture, dust and dirt out. The casing shall be of cast iron, ductile iron, or heavy-duty steel construction with lifting lugs and an inspection cover for each gear train. An oil level sight glass and an oil flow indicator shall be provided, located for easy reading.
- C. Gears and gear drives that are part of an equipment assembly shall be shipped fully assembled for field installation.
- D. Material selections shall be selected by the manufacturer, provided the above AGMA values are met. Input and output shafts shall be adequately designed for the service and load requirements. Gears shall be computer-matched for minimum tolerance variation. The output shaft shall have 2 positive seals to prevent oil leakage.
- E. Oil level and drain locations shall be easily accessible. Oil coolers or heat exchangers with required appurtenances shall be provided when necessary.
- F. Where gear drive input or output shafts from one manufacturer connect to couplings or sprockets from a different manufacturer, the Contractor shall have the gear drive manufacturer furnish a matching key taped to the shaft for shipment.

2.06 DRIVE CHAINS

- A. Power drive chains shall be commercial type roller chains meeting ASME Standards.
- B. A chain take-up or tightener shall be provided in every chain drive arrangement to provide easy adjustment.
- C. A minimum of one connecting or coupler link shall be provided in each length of roller chain.

- D. Chain and attachments shall be of the manufacturer's best standard material and be suitable for the process fluid.

2.07 SPROCKETS

- A. General: Sprockets shall be used in conjunction with chain drives and chain-type material handling equipment.
- B. Materials: Unless otherwise indicated, materials shall be as follows:
 - 1. Sprockets with 25 teeth or less, normally used as a driver, shall be made of medium carbon steel in the 0.40 to 0.45 percent carbon range.
 - 2. Type A and B sprockets with 26 teeth or more, normally used as driven sprockets, shall be made of minimum 0.20 percent carbon steel.
 - 3. Large diameter sprockets with Type C hub shall be made of cast iron conforming to ASTM A 48, Class 30.
- C. Sprockets shall be accurately machined to ASME Standards. Sprockets shall have deep hardness penetration in tooth sections.
- D. Finish bored sprockets shall be furnished complete with key seat and set screws.
- E. To facilitate installation and disassembly, sprockets shall be of the split type or shall be furnished with Taper-Lock bushings as required.
- F. Idler sprockets shall be provided with brass or Babbitt bushings, complete with oil hole and axial or circumferential grooving with stainless steel tubing and grease fitting extended to an accessible location. Steel collars with set screws may be provided in both sides of the hub.

2.08 V-BELT DRIVES

- A. V-belts and sheaves shall be of the best commercial grade and shall conform to ASME, MPTA, and RMA Standards.
- B. Unless otherwise indicated, sheaves shall be machined from the finest quality gray cast iron.
- C. Sheaves shall be statically balanced. In some applications where vibration is a problem, sheaves shall be dynamically balanced. Sheaves operating at belt speeds exceeding 6,500 fpm may be required to be of special materials and construction.
- D. To facilitate installation and disassembly, sheaves shall be provided complete with Taper-Lock or QD bushings as required.
- E. Finish bored sheaves shall be complete with key seat and set screws.
- F. Sliding motor bases shall be provided to adjust the tension of V-belts.

2.09 DRIVE GUARDS

- A. Power transmission trains, prime movers, machines, shaft extensions, and moving machine parts shall be guarded to conform to the OSHA Safety and Health Standards (29CFR1910). The guards shall be constructed of minimum 10-gauge expanded, flattened steel with smooth edges and corners, galvanized after fabrication, and securely fastened. Where required for lubrication or maintenance, guards shall have hinged and latched access doors.

2.10 BEARINGS

- A. General: All bearings shall be selected and sized by the equipment manufacturers and reviewed by bearing manufacturers. Bearing life calculation shall be submitted and reviewed by bearing manufacturer. Bearing shall conform to the standards of the American Bearing Manufacturers Association, Inc. (ABMA).
- B. To assure satisfactory bearing application, ambient temperature, humidity, internal clearances, fitting practice, mounting, lubrication, sealing, static rating, housing strength, and lubrication shall be considered in bearing selection.
- C. Re-lubricatable type bearings shall be equipped with hydraulic grease fitting in an accessible location and shall have sufficient grease capacity in the bearing chamber.
- D. Lubricated-for-life bearings shall be factory-lubricated with the manufacturer's recommended grease to insure maximum bearing life and best performance.
- E. Anti-Friction Type Bearing Life: Except where otherwise indicated, bearings shall have a minimum L-10 life expectancy of 5 years or 20,000 hours, whichever occurs first. Where so indicated, bearings shall have a minimum rated L-10 life expectancy corresponding to the type of service, as follows:

Type of Service	Design Life, years	L-10 Design Life, hours
	(whichever comes first)	
8-hour shift	10	20,000
16-hour shift	10	40,000
Continuous	10	60,000

- F. Bearing housings shall be of cast iron or steel and bearing mounting arrangement shall be as indicated or as recommended in the published standards of the manufacturer. Split-type housings may be used to facilitate installation, inspection, and disassembly.
- G. Sleeve Type Bearings: Sleeve-type bearings shall have a cast iron or ductile iron housing and Babbitt or bronze liner. Bearing housing shall be bolted and doweled to the lower casing half. These housings shall be provided with cast iron caps bolted in place and the bearing end caps shall be bored to receive the bearing shells. Sleeve bearings shall be designed on the basis of the maximum allowable load permitted by the bearing manufacturer. If the sleeve bearing is connected to an equipment shaft with a coupling, the coupling transmitted thrust will be assumed to be the maximum motor or equipment thrust. Lubricant, lubrication system, and cooling system shall be as recommended by the bearing manufacturer.

- H. Plate Thrust Bearings: Thrust bearings shall be the Kingsbury Type, designed and manufactured to maintain the shaft in the fixed axial position without undue heating or the necessity of adjustment or attention. Bearings shall be oil lubricated to suit the manufacturer's standard method of lubrication for the specific bearing. If bearing cooling is required, manufacturer shall provide heat exchangers, including necessary instrumentation and controls, piping, filters, and valves.

2.11 PIPING CONNECTIONS

- A. Pipe Hangers, Supports, and Guides: Pipe connections to equipment shall be supported, anchored, and guided to avoid stresses and loads on equipment flanges and equipment. Supports and hangers shall be in accordance with Section 40 05 07– Hangers and Supports for Process Piping.
- B. Flanges and Pipe Threads: Flanges on equipment and appurtenances shall conform to ASME B16.1, Class 125, or B16.5, Class 150, unless otherwise indicated. Pipe threads shall be in accordance with ASME B1.20.1 and Section 40 05 01– Piping General.
- C. Flexible Connectors: Flexible connectors shall be installed in piping connections to engines, blowers, compressors, and other vibrating equipment and in piping systems in accordance with the requirements of Section 40 05 01– Piping General. Flexible connectors shall be harnessed or otherwise anchored to prevent separation of the pipe where required by the installation.
- D. Insulating Connections: Insulating bushings, unions, couplings, or flanges, as appropriate, shall be used in accordance with the requirements of the specifications.

2.12 GASKETS AND PACKINGS

- A. Gaskets and packings shall be in accordance with the requirements of the specifications. Gaskets and packings in contact with drinking water shall be NSF 61 approved. Elastomeric materials in contact with water with chloramines, or water with ozone residual shall be made of Teflon or Viton-A, or equal.
- B. Packing around valve stems and reciprocating shafts shall be of compressible material, compatible with the fluid being used. Chevron-type "V" packing shall be Garlock No. 432, John Crane Everseal, or equal.
- C. Packing around rotating shafts (other than valve stems) shall be "O" rings, stuffing boxes, or mechanical seals, as recommended by the manufacturer and approved by the Engineer, in accordance with Section 43 20 00 - Pumps, General.

2.13 NAMEPLATES

- A. Equipment nameplates of stainless steel shall be engraved or stamped and fastened to the equipment in an accessible location with No. 4 or larger oval head stainless steel screws or drive pins. Nameplates shall contain the manufacturer's name, model, serial number, size, characteristics, and appropriate data describing the machine performance ratings.

2.14 SPECIAL TOOLS AND SPARE PARTS

- A. Tools: The Contractor shall furnish one complete set of special wrenches and other special tools necessary for the assembly, adjustment, and dismantling of the equipment. Tools shall be of best quality hardened steel forgings with bright finish. Wrench heads shall have work faces dressed to fit nuts. Tools shall be suitable for professional work and manufactured by Snap On, Crescent, Stanley, or equal. The set of tools shall be neatly mounted in a labeled toolbox of suitable design provided with a hinged cover.
- B. Spare parts shall be furnished as indicated in the individual equipment sections. Spare parts shall be suitably packaged in a metal box and labeled with equipment numbers by means of stainless steel or solid plastic nametags attached to the box.]]]

2.15 EQUIPMENT LUBRICANTS

- A. The Contractor shall provide lubricants for equipment during shipping, storage, and prior to testing, in accordance with the manufacturer's recommendations. Lubricants that could come in contact with potable water shall be food grade lubricants. After successful initial testing, final testing, and satisfactory completion startup testing per Section 01 75 00 - Equipment Testing and Plant Startup, the Contractor shall conduct one complete lubricant change on equipment. In addition, the Contractor shall be responsible for the proper disposal of used lubricants. The Owner will then be responsible for subsequent lubricant changes

PART 3 -- EXECUTION

3.01 SERVICES OF MANUFACTURER CONTRACTOR

- A. Installation Supervision, Inspection, Startup, and Field Adjustment: An authorized, experienced, and competent service representative of the manufacturer shall visit the Site to perform the following:
 - 1. Supervision of the installation of the equipment.
 - 2. Inspection, checking, and adjusting the equipment and approving its installation.
 - 3. Startup and field testing for proper operation, efficiency, and capacity.
 - 4. Performing field adjustments during the test period to ensure that the equipment installation and operation comply with requirements.
 - 5. Verify, affirm and certify that the specified equipment performance acceptance criteria and conditions such as temperature and vibration amplitude, have been meet. Submit test certificate signed by the Contractor and witnessed by the Engineer representative.
 - 6. Certify in writing that the equipment and controls have been properly installed, aligned, lubricated, adjusted, and readied for operation.
 - 7. Unless otherwise indicated, factory representative shall be present at the job site for the following number of days:
 - a. Half a day per equipment for smaller than 500 horsepower.
 - b. One day per equipment for 500 horsepower and larger.

B. Owner Staff Training

1. Owner staff training shall be in accordance with Section 01 79 00– Owner Staff Training. An authorized training representative of the Manufacturer shall visit the site for a number of days indicated in those sections to instruct the Owner's personnel in the operation and maintenance of the equipment, including step by step troubleshooting with necessary test equipment. Instruction shall be specific to the models of equipment provided.
2. The representative shall have at least two years' experience in training. A resume of the representative shall be submitted.
3. Unless otherwise indicated, a minimum of one day of training shall be provided for each type of equipment.

3.02 TESTING

A. General requirements

1. All mechanical equipment shall undergo factory and field performance and functional test to demonstrate that the process equipment system meet the requirement of the Contract Document. Detailed testing requirement are specified in each equipment specification sections.
2. Unless otherwise specified, equipment factory testing procedure shall follow the Industry Standard test procedure that applies to that equipment.
3. Submit test procedures for review by the engineer one month prior to the scheduled test.

B. Test sequence

1. Factory functional and performance testing
2. Component tests
3. System tests
4. Individual system or train test
5. Overall facility operational tests

3.03 STARTUP AND COMMISSIONING

- A. Startup and commissioning test shall be as specified in Division1

3.04 PACKAGED EQUIPMENT

- A. When any system is furnished as pre-packaged equipment, the Contractor shall coordinate space and structural requirements, clearances, utility connections, signals, and outputs with Subcontractors to avoid later change orders.
- B. If the packaged system has any additional features (such as safety interlocks, etc.) other than required by the Contract Documents, the Contractor shall coordinate such features with the Engineer and provide material and labor necessary for a complete installation as required by the manufacturer.

3.05 FIELD ASSEMBLY

- A. Studs, cap screws, bolt and nuts used in field assembly shall be coated with Never Seize compound or equal.

3.06 FIELD TESTS

- A. Where indicated by the individual equipment sections, equipment shall be field tested after installation to demonstrate satisfactory operation without excessive noise, vibration, or overheating of bearings or motor.
- B. The following field testing shall be conducted:
 - 1. Operational Readiness Tests (ORT)
 - a. Check equipment for proper installation, baseplates leveled, grouted and anchor bolts properly torqued to manufacturer's specifications and rotating assemblies balanced and shafts aligned.
 - b. Install all instruments and their associated components, controls panels, wirings are installed, calibrated and termination checked.
 - c. Install and check all PLC's, Input/output wires and all terminations.
 - d. Install all power cables from MCC to motors and checked.
 - 2. Perform trial operation. Start equipment, check, and operate the equipment over its entire operating range. Vibration level shall be within the amplitude limits as indicated or as recommended by the reference applicable standards.
 - 3. Obtain concurrent readings of motor voltage, amperage, capacity, vibration, and bearing temperatures.
 - 4. Operate equipment indicated in Section 01 75 00- Equipment Testing and Plant Startup.
- C. The Engineer shall witness field-testing. The Contractor shall notify the Engineer of the test schedule 3 Days in advance.
- D. In the event that any equipment fails to meet the test requirements, the equipment shall be modified and retested until it satisfies the requirement.

END OF SECTION

