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CALICO PHASE 2 ADVANCE WASTEWATER TREATMENT PROJECT

FOR

CALICO GHOST TOWN REGIONAL PARK
YERMO, CALIFORNIA
PROJECT NO.: 30.30.0074

WARNING

ALL INDIVIDUALS INTERESTED IN BIDDING ON THIS PROJECT MUST OBTAIN THE FINAL DESIGN PLANS AND SPECIFICATIONS FROM THE DEPARTMENT MANAGING THE PROJECT OR AS OTHERWISE STATED IN THE ADVERTISEMENT FOR BIDS FOR THE PROJECT. DO NOT USE THE PLANS AND SPECIFICATIONS POSTED ON THE CLERK OF THE BOARD'S WEBSITE FOR BIDDING THE PROJECT.

SECTION 260000 – GENERAL ELECTRICAL REQUIREMENTS

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following:

1. General requirements which apply to all electrical aspects of the work.

B. Related Sections

1. The Contract Documents are a single integrated document. As such, all Divisions and Sections are applicable. The Contractor and its Subcontractors are responsible to review all parts of the Contract Documents in order to provide a complete and coordinated project.

1.2 REFERENCES

A. The installation and commissioning of the Electrical System shall conform to all applicable codes, regulations, standards and specifications, including, but not limited to those listed below. These publications are referenced to by designation but not by edition. The latest edition accepted by the Authority Having Jurisdiction in effect at the time of bid shall govern.

1. State and Local Codes and Authority Having Jurisdiction (AHJ)
2. National Electric Code (NEC).
3. National Fire Protection Association (NFPA)
4. Institute of Electrical and Electronic Engineers (IEEE)
5. American National Standards Institute (ANSI)
6. American Society for Testing and Materials (ASTM)
7. Insulated Cable Engineers Association (ICEA)
8. National Electrical Manufacturers Association (NEMA)
9. Federal Occupational Safety and Health Act (OSHA)
10. Underwriters Laboratories, Inc. (UL)
11. International Society of Automation (ISA)

1.3 DEFINITIONS

A. Refer to the Contract Drawings sheet GE-01 for a list of abbreviations associated with the Electrical System. In addition, the following definitions are used in this section:

1. AHJ – Authority Having Jurisdiction
2. I&C – Instrumentation and Controls
3. IS – Instrumentation Supplier
4. NEC – National Electric Code
5. VFD – Variable Frequency Drive
6. UL - Underwriters Laboratories, Inc.

1.4 ELECTRICAL SYSTEMS REQUIREMENTS

A. The Work is to provide all labor and materials necessary for erecting a complete and operational Electrical System, tested and ready for continuous use as described by the Contract Documents. The Electrical System shall be constructed in accordance with the Contract Documents, and Federal, State, and Local codes and regulations. In addition, the Work shall adhere to the following general provisions:

1. The Electrical Contractor shall obtain all necessary permits required by the AHJ. In addition, the Electrical Contractor shall ensure that all inspections required by the AHJ are coordinated, conducted and documented.

2. All work shall be completed in a neat, workmanlike manner in accordance with the latest NEC standards of installation under competent supervision.

3. The Electrical Contractor shall visit the job site prior to bidding to become familiar with existing conditions and other factors, which may affect the execution of the work. Include all related costs in the initial bid proposal.

4. Coordinate work with the utilities providing services on this project. This may include but is not limited to the electric utility, telephone utility, cable TV/Internet utility. All electrical work associated with utilities shall be provided and installed per the utility requirements.

5. All materials shall be new and of the best quality, manufactured in accordance with the requirements listed in part 1.2 of this section. The Contractor shall furnish and install the parts and pieces necessary to the installation of equipment, in accordance with the best practice of the trade, and in conformance with the requirements of these Contract Documents.

6. Protect all electrical material and equipment that is being stored or has been installed against damage by other trades, weather conditions, or any other preventable causes. Equipment damaged during shipping, storage or construction, prior to acceptance by the engineer or the owner, will be rejected as defective.

7. Leave the site clean. Remove all debris, empty cartons, tools, conduit, wire scraps and all miscellaneous spare equipment and materials used in the work during construction. All components shall be free of dust, grit and foreign materials, left as new before final acceptance of work. Damaged paint and finishes shall be touched up or repainted with matching color paint and finish.

8. Electrical equipment shall be capable of operating successfully at full-rated load, without failure, at an ambient air temperature of 40 degrees C, and specifically rated for the altitude indicated on the Plans. Electrical equipment not rated for operation at that temperature shall be provided with air conditioning to meet the manufacturers' operating temperature.

9. If any contradictions, contrasts, non-homogeneity, or inconsistency appears, the most strict criteria noted and the collective requirements in any and all of the Contract Documents shall apply.

10. The Electrical Contractor shall perform necessary saw cutting, core drilling, excavating, removal, shoring, backfilling, and other work required for the proper installation of conduits, whether inside, or outside of the buildings and structures. The Electrical Contractor shall repair and patch where demolition has taken place in a manner to match existing original structure.

B. In order to provide a complete system, oversee and coordinate with all electrical equipment and services being provided outside of Contractor's scope.

1. The Engineer is responsible to ensure that equipment being supplied by others related to the electrical system complies with the requirements of the Contract Documents

2. The Electrical Contractor is responsible to coordinate the installation, commissioning and scheduling of equipment related to the I&C System that are provided by others.

C. Oversee and coordinate with all equipment and services being provided by the Contractor but outside of the Electrical Contractor's scope.

1. Inform all vendors and suppliers providing equipment related to the Electrical System the requirements of Division 26.

2. The Owner is not responsible for any additional costs incurred by requiring vendors and/or subcontractors to meet the requirements of Division 26.

3. If a vendor or supplier is unable to meet the requirements of Division 26, the Contractor may submit in writing to the Engineer the reasons for non-compliance. The Engineer will then evaluate the reasons and determine whether a solution may be determined or if a different vendor or supplier is required.

D. Prepare Electrical System Submittals as required by Division 26 and Section 01 33 00 "Contractor Submittals". Coordinate with the IS and the requirements of Division 40 to ensure that all equipment being supplied by the Electrical Contractor and/or IS has been submitted.

E. Oversee the installation of the Electrical System.

F. Actively participate in loop testing as outlined in Division 40.

G. Actively participate in commissioning as outlined in Division 40.

H. Maintain record drawings.
1. Maintain on the construction site a set of the Electrical Drawings that shall be continuously marked up during construction.
   a. The drawings should be updated at least weekly and will be checked monthly by the Owner's representative.
   b. Upon completion of startup, submit the marked up drawings to the Engineer for review and for drafting.

I. Prepare O&M manuals.
1. Provide O&M manuals in accordance with Section 01 78 23 "Operation and Maintenance Data".

J. Provide training on electrical equipment that has been installed.

1.5 ACTION SUBMITTALS

A. General
   1. Submittals for Division 26 shall meet the requirements of Section 01 33 00 “Contractor Submittals”. In addition, the following requirements shall be met:
      a. Submittals shall include bills of materials with quantities, makes, models, exact part numbers and descriptions.
      b. Edit all submittals such that only pertinent information is submitted. Neatly cross out information that does not apply, options that are not being supplied, etc.
      c. Show product dimensions, construction and installation details, wiring diagrams, and specifications.
      d. If there are exceptions to the Contract Drawings and Specifications, provide a list of exceptions with detailed explanations for the exceptions. The Engineer will review the list of exceptions and determine whether a solution may be determined or if the exception(s) will not be allowed.
   2. Furnish submittals required by each Section within Division 26.
   3. When submitting on equipment, use the equipment and instrumentation tags depicted in the Contract Drawings.

B. Recommended Spare Parts Submittal
   1. Submit a list of spare parts for all of the equipment associated with the Electrical System. The list of spare parts shall include list pricing for each item.
   2. Provide the name, address and phone number for each manufacturer and manufacturer’s local sales representative.
   3. Indicate whether or not the spare parts are being provided under this contract or not.

1.6 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.7 QUALITY ASSURANCE

A. All equipment supplied for this project shall meet the requirements of the NEC and shall be listed by and bearing the label of the UL.

B. The Electrical Contractor shall be a company that has been actively involved in the installation and commissioning of Electrical Systems for a minimum period of five years.

C. The Electrical Contractor shall have adequate facilities, manpower and technical expertise to perform the Work associated with the Electrical System and as outlined by the Contract Documents.

D. The Electrical Contractor shall have similar project experience of at least four successfully completed projects for a similar wastewater system. The Electrical Contractor company must have performed similar work for these projects as required herein.

PART 2 - PRODUCTS

2.1 MATERIALS AND METHODS

A. Materials, equipment, and parts comprising any unit, or part thereof, specified or indicated on the Plans, shall be new and unused, of current manufacture, and of highest grade consistent with the state of the art. Damaged or dirty materials, equipment, and parts, are not considered to be new and unused, and will not be accepted.

B. Field verification of scale dimensions on Plans is directed, since actual locations, distances, and levels will be governed by actual field conditions. The Contractor shall also review architectural, structural, yard, mechanical, and other Plans, and the accepted electrical and mechanical shop drawings, and shall adjust their work to conform to the conditions indicated therein.

C. The fabricator of major components, such as distribution panelboards, switchgear, and motor control centers, shall also be the manufacturer of the major devices therein. Where possible, the major components shall be manufactured and supplied by the same fabricator.

2.2 MANUFACTURERS

A. All equipment provided for the Electrical System 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.

B. Refer to various Division sections for individual equipment manufacturers. Indicated manufacturers are subject to strict compliance with the specifications and complete project documents. The reference to a particular manufacturer does not relieve the Electrical Contractor from conforming to the specified requirements.

C. When providing like electrical components they shall be furnished by a single manufacturer and shall be consistent throughout the project. For example, a 20A 2-way light switch in one building should match a 20A 2-way light switch in another building in both make, model and features.

2.3 EQUIPMENT ASSEMBLIES

A. Equipment assemblies, such as Service Entrance Sections, Switchgear, Switchboards, Control and Distribution Panels, and other custom fabricated electrical enclosures shall bear a UL label as a complete assembly. The UL label on the individual components making up the assembly will not be considered sufficient to meet the present requirement. Whenever a generic UL label does not apply for the assembly, a serialized UL label shall be affixed to the assembly, and the serial number shall be submitted with the assembly record shop drawings.

B. Custom fabricated electrical control panels, and enclosures shall bear a serialized UL label affixed by a local inspector, and the serial number shall be submitted with the assembly record shop drawings.

2.4 OPERATING CONDITIONS

A. The Electrical System shall be designed and constructed for satisfactory operation and long, low maintenance service under the following conditions:
   1. Environment: Type the type of facility this is for such as “Wastewater Treatment Plant”.
   2. Temperature Extremes: 30°F to 122 °F (Outdoors); 40°F to 104 °F (Indoors).
   3. Relative Humidity: 20% to 90%, non-condensing.

B. Indoor and outdoor electrical equipment 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 electrical devices 20 percent within the minimums and maximums of their rated environmental operating ranges. The Contractor shall provide power wiring for these devices. Enclosures suitable for the environment shall be furnished. Electrical equipment in hazardous areas shall be suitable for and rated for use in the particular hazardous or classified location in which it is to be installed.

2.5 SEISMIC RESTRAINT

A. The construction area is classified by the International Building Code (IBC) as Seismic Class C. The Code requires that not only the structures, but also major electrical components be designed and installed in a manner which will preclude damage during a seismic event. All electrical equipment shall be securely anchored and seismic braced in accordance with regulations contained in the most recent adopted edition of the IBC, and the Sheet Metal and Air Conditioning Contractor’s National Association (SMACNA) "Guidelines for Seismic Restraints of Electrical Systems".

B. Units mounted and secured directly to structure shall be provided with connectors of sufficient strength to meet the restraining criteria.

C. All electrical equipment which is securely anchored (hard mounted) to the building or structure shall have supports designed to withstand lateral and vertical "G" loadings equal to or greater than IBC requirements and SMACNA guidelines.

D. Shop drawings are required for all equipment anchors, supports and seismic restraints. Submittals shall include weights, dimensions, load/deflection data, center of gravity, standard connections, manufacturer's recommendations, and behavior problems (vibration, thermal, expansion, etc.) associated with equipment.

2.6 SPECIAL TOOLS

A. The Electrical Contractor shall furnish a priced list of special tools required to maintain the electrical equipment provided. The Owner and Engineer will select which tools are to be purchased and the IS will supply them at the prices listed.

B. Special tools shall be delivered to the Owner before startup commences.

PART 3 - EXECUTION

3.1 DELIVERY, STORAGE AND HANDLING

A. After completion of shop assembly, factory test, and approval, equipment, cabinets, panels, and consoles 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 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. Each component shall be tagged to identify its location, instrument tag number, and function in the system. A permanent stainless steel or other non-corrosive material tag firmly attached and permanently and indelibly marked with the instrument tag number, as given in the tabulation, shall be provided on each piece of equipment in the PCIS. Identification shall be prominently displayed on the outside of the package.

D. Equipment shall not be stored outdoors. Equipment shall be stored in dry permanent shelters, including in-line equipment, and shall be adequately protected against mechanical injury. If any apparatus has been damaged, such damage shall be repaired by the Contractor. If any apparatus has been subject to possible injury 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 MANUFACTURER'S SERVICES

A. Manufacturer's services shall be furnished for the following equipment:
   1. Vendor supplied equipment that contain programmable controllers, operator interfaces and/or instrumentation that requires site calibration.
   2. Equipment that is equipped with VFD's
   3. Electrical generation equipment
   4. Switchgear

3.3 INSTALLATION

A. The Electrical System indicated throughout the design is diagrammatic and therefore locations of equipment are approximate. 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. Installation of systems and equipment is subject to clarification as indicated in reviewed shop drawings and field coordination. 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.

B. Discrepancies indicated on different Plans, between Plans and actual field conditions, or between Plans and Contract Documents shall be promptly brought to the attention of the Engineer for clarification, prior to purchasing and installing equipment.

C. The alignment of equipment and conduit shall be adjusted to accommodate architectural changes, or to avoid work of other trades, without extra expense to the Owner.

D. Items not specifically mentioned in these Contract Documents, or noted on the Plans, or indicated on reviewed shop drawings, but which are obviously necessary to make a complete working installation, shall be deemed to be included herein.

E. The Electrical Contractor shall layout and install electrical work prior to placing floors and walls. Furnish and install sleeves and openings through floors and walls, required for installation of conduits. Sleeves shall be rigidly supported and suitably packed, or sealed, to prevent ingress of wet concrete. Spacers shall be installed in order to prevent conduit movement. Dimensions indicated for electrical equipment and their installation are restrictive dimensions.

F. The Electrical Contractor shall furnish and install inserts and hangers required to support conduits and other electrical equipment. If the inserts, hangers, sleeves, or other mounting hardware are improperly placed, or installed, the Contractor shall do necessary work, at their own expense, to rectify the errors.

G. The Electrical System is integrally connected to I&C, mechanical and structural systems. Coordinate with these other disciplines the installation of these related components.

H. Electrical equipment shall be anchored by methods that comply with seismic requirements applicable to the Site.

I. The Contract Documents show necessary conduit and instruments required to make a complete instrumentation system. 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.

J. Instrumentation, control panels, wiring and all other I&C equipment shall be properly tagged and/or labeled per the requirements of Section 26 05 53 “Identification for Electrical Systems”.

K. Installation of the I&C System shall be according to the finalized Loop Drawings

3.4 FACTORY ACCEPTANCE TESTING (FAT)

A. The IS shall arrange for the manufacturers of the equipment and fabricators of panels and cabinets supplied under this Section to allow the Engineer and Owner to inspect and witness the testing of the equipment at the site of fabrication. Equipment shall include the cabinets, special control systems, and other pertinent systems and devices. A minimum of 10 days notification shall be furnished to the Engineer prior to testing. No shipments shall be made without the Engineer's approval.

B. For each FAT, the IS shall develop and submit a FAT Plan and Procedure Document within 10 days of the FAT. The FAT Plan and Procedure shall as a minimum shall have the following:
   1. Descriptions of test methods to be performed during the FAT.
   2. FAT Schedule and Procedure
   3. FAT Checklists that allow for sign-off and comments for each test method and procedure.

C. Control Panel Completion Test Methods: The following test methods should be performed during the FAT for each control panel:
   1. Completed Shop Drawings: Demonstrate that the control panel has been built according to the shop drawings and that the shop drawings are accurate.
   2. Panel Layout: Demonstrate that the control panel has been laid out as designed and as required by Division 40.
   3. Power Distribution: Demonstrate all power distribution circuits, including but not limited to AC power circuits, UPS operation, signals and circuits and DC circuits.
   4. Control Circuits: Demonstrate the correct installation of each control circuit. Using a signal generator or multi-meter, show the correct operation of each input, output, relay, barrier, buttons, switches, or any other control device. Demonstrate the proper functionality of any hard-wired interlocks that may be associated with each control circuit.
   5. Panel Networking/Communications: If any form of communications is associated with the control panel, verify the proper operation of each communication port and link.

D. Control Loop Test Methods: In order to demonstrate that the control panel will provide its function as intended, provide the following control loop test methods. If programming for the control panel is provided by others, coordinate with the programmer to have all programming completed and tested prior to the FAT. If needed, coordinate to have the programmer present for the FAT.
   1. Alarm Functions: Verify and/or simulate each alarm condition associated with each control loop.
   2. Local Manual and Auto Functions: Verify and/or simulate each Local Manual and/or Auto function associated with each control loop.
   3. SCADA Manual and Auto Functions: Verify and/or simulate each SCADA Manual and/or Auto function associated with each control loop.
   4. Control Loop Interlocks: Demonstrate the functionality of any software interlocks that may be associated with each control loop.

E. If the FAT does not pass and needs to be repeated, the IS shall be responsible for additional per diem costs incurred by the Engineer and Owner.

F. All changes and/or corrections made during the FAT shall be noted on the checklists.

G. Following completion and approval of all FAT, provide the finalized checklists to the Engineer and as part of the equipment shop drawings.

3.5 FIELD QUALITY CONTROL

A. Allow for inspections by the Engineer and/or Owner of the I&C System at any time during the construction. Inspections shall be conducted to verify that the installation is per the requirements of the Contract Documents.

3.6 CALIBRATION

A. As specified in Section 408000 “Commissioning of Process Systems”.

3.7 LOOP TESTING

A. As specified in Section 408000 “Commissioning of Process Systems”.

3.8 COMMISSIONING

A. As specified in Section 408000 “Commissioning of Process Systems”.

3.9 TRAINING

A. Provide training in accordance with Section 260000 “General Electrical Requirements”.

B. Develop a Training Plan for the training requirements of Division 40 and submit it to the Engineer for approval. Coordinate with the Engineer and Owner the time and locations of each training session. Schedule the trainings for after the equipment has been pre-commissioned.

C. As part of the Training Plan, submit a résumé for each individual to be providing training. Training shall be performed by qualified representatives of the equipment manufacturers and shall be specific to each piece of equipment.

D. Each training session shall include a written agenda.

E. The Contractor shall train the Owner’s personnel on the maintenance, calibration and repair of instruments provided.

F. Within 10 days after the completion of each session, the Contractor shall submit the following:
   1. A list of Owner personnel who attended the training.
   2. A copy of the training materials used during the session with notes, diagrams and comments.

END OF SECTION 260000

SECTION 260519 - LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following:

1. Building wires and cables rated 600 V and less.
2. Connectors, splices, and terminations rated 600 V and less.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product indicated.

1.3 INFORMATIONAL SUBMITTALS

A. Field quality-control test reports.

1.4 QUALITY ASSURANCE

A. 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.

B. Comply with NFPA 70.

PART 2 - PRODUCTS

2.1 CONDUCTORS AND CABLES

A. All conductors, conductor insulation and multiconductor cables shall comply with NEMA WC 70.

B. Wire sizes shall be American Wire Gauge (AWG) sizes with Class B stranded construction Number 2 AWG and smaller shall be factory color coded with a separate color for each phase and neutral, which shall be used consistently throughout the system. Larger cables shall be coded by the use of colored tape. Conductors #6 AWG or smaller shall be THWN-2 or XHHW-2. Number 4 and larger shall be XHHW-2.

C. Individual or multiple conductor cables for power, control, and alarm circuits of 480 volts or less shall be insulated for not less than 600V.

D. Where wire size is not indicated, they shall be of the size required by the NEC, except that no wire external to panels and motor control centers shall be less than #12 AWG, unless specifically noted on the Plans. Control wires shall be allowed to be #14 so long as there is appropriate protection (fuse or circuit breaker sized at 15A or less).

E. Multi-conductor tray cables shall be rated 600 volts, listed by UL as Type TC cable or ITC for instrumentation cable only per Article 340 of the NEC. The individual conductors shall be UL listed as Type XHHW, with a sunlight-resistant overall jacket. Conductor sizes shall be the same as for power and lighting wire and control wire above. Connectors/Terminators shall be water tight and manufactured of the same material as the cabling system referenced elsewhere in division 26.

F. Multi-conductor tray cables to be installed in classified areas shall be armored, rated 600 volts, listed by UL as Type MC-HL cable per Article 340 of the NEC. The individual conductors shall be UL listed as Type XHHW, with a sunlight-resistant overall jacket. Conductor sizes shall be the same as for power and lighting wire and control wire above. Connectors/terminators shall be rated for classified areas and submitted upon accordingly.

G. All wiring shall be as indicated on the Plans. Wires shall be new and shall be soft drawn copper with not less than 97 percent conductivity. The wire and cable shall have size, grade of insulation, voltage, and manufacturer's name permanently marked on the outer covering at not more than 2-foot intervals. All wires shall conform to the latest Standards of the ASTM, and ICEA, and shall be tested for their full length by these Standards. Insulation thickness shall be not less than that specified by the National Electrical Code.

H. VFD Cable:

1. Comply with UL 1277, UL 1685, and NFPA 70 for Type TC-ER cable.
2. Type TC-ER with oversized crosslinked polyethylene insulation, spiral-wrapped foil plus 85 percent coverage braided shields and insulated full-size ground wire, and sunlight- and oil-resistant outer PVC jacket.
3. Comply with UL requirements for cables in direct burial or Classes I and II, Division 2 hazardous location applications.

I. The following table describes the conductor color code that shall be followed:

	120/208VAC	**480VAC**	**12VDC**	**24VDC**	**24VAC**
Phase 1	Black	Brown			
Phase 2	Red	Orange			
Phase 3	Blue	Yellow			
Neutrals/Commons	White	White	Orange/White	Blue/White	Yellow/White
Ground	Green	Green	Green	Green	Green
Control	Red		Orange	Blue	Yellow

J. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. American Insulated Wire Corporation
2. Cablec Corporation

3. Okonite Company
4. Southwire Company
5. Or Approved Equal

2.2 CONNECTORS AND SPLICES

A. Description: Factory-fabricated connectors and splices of size, ampacity rating, material, type, and class for application and service indicated.

B. Connectors and splices shall be rated at not less than 600 volts. Splicing shall join conductors mechanically and electrically to provide a complete circuit prior to installation of insulation.

C. Splices in wires No. 10 AWG and smaller shall be made with an insulated, solderless, pressure type connector, Type I, Class 1, Grade B, Style G, or Type II, Class 1 of FS W-S-610 and conforming to the applicable requirements of UL 486A.

D. Splices in wires No. 8 AWG and larger shall be made with non-insulated, solderless, pressure type connector, Type II, Class 2 of FS W-S-610, conforming to the applicable requirements of UL 486A and UL 486B. They shall then be covered with an insulation and jacket material equivalent to the conductor insulation and jacket.

E. Insulated conductor splices below grade or in wet locations shall be sealed type conforming to ANSI C119.1 or shall be waterproofed by a sealant-filled, thick wall, heat shrinkable, thermosetting tubing or by pouring a thermosetting resin into a mold that surrounds the joined conductors.

F. Bare conductor splices in wet locations or below grade shall be of the exothermic type.

G. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Hubbell Power Systems, Inc.
2. O-Z/Gedney; EGS Electrical Group LLC.
3. 3M; Electrical Products Division.
4. Or Approved Equal

2.3 PULLING LUBRICANT

A. All cables shall be properly coated with a water-based (wax-based is not acceptable) pulling compound before being pulled into conduits so as to prevent mechanical damage to the cables during installation. Lubricants shall be approved by the cable manufacturer for use with the cable being installed.

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Polywater
2. Ideal Aqua-Gel
3. Or Approved Equal

PART 3 - EXECUTION

3.1 CONDUCTOR MATERIAL APPLICATIONS

A. Feeders: Copper. Stranded for all sizes.

B. Branch Circuits: Copper. Stranded for all sizes.

3.2 CONDUCTOR INSULATION AND MULTICONDUCTOR CABLE APPLICATIONS AND WIRING METHODS

A. Service Entrance: Type XHHW-2, single conductors in raceway

B. Exposed Feeders and Branch Circuits: Type THWN-2 or XHHW-2 based on wire size requirements described in Part 2, single conductors in raceway. Multiconductor Tray Cable type TC shall be used where runs are to be in cable trays as shown on the drawings.

C. Feeders and Branch Circuits Concealed in Ceilings, Walls, Partitions, and Crawlspaces: Type THWN-2 or XHHW-2 based on wire size requirements described in Part 2, single conductors in raceway. Metal-clad cable, Type MC shall be allowed in ceilings that are considered dry and non-corrosive areas.

D. Feeders and Branch Circuits Concealed in Concrete, below Slabs-on-Grade, and Underground: Type THWN-2 or XHHW-2 based on wire size requirements described in Part 2, single conductors in raceway.

E. Cord Drops and Portable Appliance Connections: Type SO, hard service cord with stainless-steel, wire-mesh, strain relief device at terminations to suit application.

F. Class 1 Control Circuits: Type THWN-2, in raceway. Multiconductor Tray Cable type TC shall be used where runs are to be in cable trays as shown on the drawings.

G. Class 2 Control Circuits: Type THWN-2, in raceway. Power-limited tray cable shall be used where runs are to be in cable tray as shown on the drawings.

3.3 INSTALLATION OF CONDUCTORS AND CABLES

A. Conceal cables in finished walls, ceilings, and floors, unless otherwise indicated.

B. As far as practical, all circuits shall be continuous from origin to termination without splices in intermediate pull boxes. Sufficient slack shall be left at the termination to make proper connections. In no case shall a splice be pulled into the conduit. Conductor splicing shall not be permitted without the Engineer's approval. Conductor splices shall not be made in underground junction boxes or manholes unless specifically noted on the plans.

C. Each feeder and branch circuit shall be installed in its own individual conduit unless combining feeder and branch circuits is permitted as defined in the following:

1. As specifically indicated on the Plans.

2. For lighting, multiple branch circuits may be installed in a conduit as allowed by the NEC and with the wire ampacity de-rated in accordance with the requirements of the NEC. Conduit fill shall not exceed the limits established by the NEC.
3. When field conditions dictate and written permission is obtained from the Engineer.

D. Use manufacturer-approved pulling compound or lubricant when pulling conductors; compound used must not deteriorate conductor or insulation. Do not exceed manufacturer's recommended maximum pulling tensions and sidewall pressure values.

E. Feeder and branch circuits shall be isolated from each other and from all instrumentation and control circuits.

F. Control circuits shall be isolated from all other feeder, branch and instrumentation circuits, except as noted above. 12VDC, 24VDC and 48VDC control circuits may be combined into one conduit. 120/208/240VAC control circuits shall be isolated from all DC control circuits. 277/480VAC circuits shall be isolated from all other voltages.

G. 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.

H. Use pulling means, including fish tape, cable, rope, and basket-weave wire/cable grips, that will not damage cables or raceway.

I. Install exposed cables parallel and perpendicular to surfaces of exposed structural members, and follow surface contours where possible.

J. Support cables according to Section 260529 "Hangers and Supports for Electrical Systems".

K. Identify and color-code conductors and cables according to Section 260553 "Identification for Electrical Systems".

L. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

M. Make splices and taps that are compatible with conductor material and that possess equivalent or better mechanical strength and insulation ratings than un-spliced conductors.

N. Wiring at Outlets and Switches: Install conductor at each outlet, with at least 6 inches (150 mm) of slack.

3.4 SLEEVE AND SLEEVE-SEAL INSTALLATION FOR ELECTRICAL PENETRATIONS

A. Install sleeves and sleeve seals at penetrations of exterior floor and wall assemblies. Comply with requirements in Section 260544 "Sleeves and Sleeve Seals for Electrical Raceways and Cabling".

3.5 FIRESTOPPING

A. Apply firestopping to electrical penetrations of fire-rated floor and wall assemblies to restore original fire-resistance rating of assembly according to Section 078413 "Penetration Firestopping".

3.6 FIELD QUALITY CONTROL

A. Perform tests and inspections and prepare test reports.

B. Tests and Inspections:

1. After installing conductors and cables and before electrical circuitry has been energized, test service entrance and feeder conductors, and conductors feeding the following critical equipment and services for compliance with requirements.

    a. All conductors with voltages at 277V or higher and corresponding neutrals and grounds.

    b. All conductors #8 and larger.
    c. All motor leads and corresponding grounds.

2. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
3. Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each splice in cables and conductors No. 3 AWG and larger. Remove box and equipment covers so splices are accessible to portable scanner.

    a. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each splice 11 months after date of Substantial Completion.
    b. Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
    c. Record of Infrared Scanning: Prepare a certified report that identifies splices checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

C. Test Reports: Prepare a written report to record the following:

1. Test procedures used.
2. Test results that comply with requirements.
3. Test results that do not comply with requirements and corrective action taken to achieve compliance with requirements.

D. Remove and replace malfunctioning units and retest as specified above.

END OF SECTION 260519

SECTION 260523 - CONTROL-VOLTAGE ELECTRICAL POWER CABLES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Instrumentation cabling.
2. Low-voltage control cabling.
3. Control-circuit conductors.
4. Identification products.

B. Related Sections

1. For structured cabling systems, including fiber optic cabling and CAT6 cabling refer to Section 409533.

1.2 DEFINITIONS

A. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or for remote-control and signaling power-limited circuits.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product indicated.

1.4 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

1.5 QUALITY ASSURANCE

A. Testing Agency Qualifications: Member company of an NRTL.

B. Surface-Burning Characteristics: As determined by testing identical products according to ASTM E 84 by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.

1. Flame-Spread Index: 25 or less.
2. Smoke-Developed Index: 50 or less.

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Test cables upon receipt at Project site.

B. Test each pair of each cable for open and short circuits.

PART 2 - PRODUCTS

2.1 PATHWAYS

A. Conduit and Boxes: Comply with requirements in Section 260533 "Raceways and Boxes for Electrical Systems."

1. Outlet boxes shall be no smaller than 2 inches wide, 3 inches high, and 2-1/2 inches deep.

2.2 INSTRUMENTATION CABLE

A. Instrument cable shall be Type TC, and have the number of individually shielded twisted pairs indicated on the Plans and shall be insulated for not less than 600 volts. Unless otherwise indicated, conductor size shall be No. 18 AWG minimum. Shielded, grounded instrumentation cable shall be used for all analog and low voltage digital signals.

B. The jacket shall be flame retardant with 90 degrees C temperature rating. The cable shield shall be a minimum of 2.3 mil aluminum or copper tape overlapped to provide 100 percent coverage and a tinned copper drain wire.

C. The conductors shall be bare soft annealed copper, Class B, 7 strand minimum concentric lay with 15 mils nominal thickness, nylon jacket, 4 mil nominal thickness, 90 degrees C temperature rating. One conductor within each pair shall be numerically identified.

D. Pairs shall be assembled with a nominal 2-inch lay and shall then be group shielded with a minimum of 1.3 mil aluminum or copper tape overlapped to provide 100 percent coverage. All group shields shall be completely isolated from each other.

E. Pairs installed in a cable tray shall have a UV resistant jacket, and shall have a jacket intended for cable tray use.

2.3 RS-232 CABLE

A. Standard Cable: NFPA 70, Type CM.

1. Paired, two pairs, No. 22 AWG, stranded (7x30) tinned-copper conductors.
2. Polypropylene insulation.
3. Individual aluminum foil-polyester tape shielded pairs with 100 percent shield coverage.
4. PVC jacket.
5. Pairs are cabled on common axis with No. 24 AWG, stranded (7x32) tinned-copper drain wire.
6. Flame Resistance: Comply with UL 1581.

B. Plenum-Rated Cable: NFPA 70, Type CMP.

1. Paired, two pairs, No. 22 AWG, stranded (7x30) tinned-copper conductors.
2. Plastic insulation.
3. Individual aluminum foil-polyester tape shielded pairs with 100 percent shield coverage.
4. Plastic jacket.
5. Pairs are cabled on common axis with No. 24 AWG, stranded (7x32) tinned-copper drain wire.
6. Flame Resistance: Comply with NFPA 262.

2.4 RS-485 CABLE

A. Standard Cable: NFPA 70, Type CM.

1. Paired, two pairs, twisted, No. 22 AWG, stranded (7x30) tinned-copper conductors.
2. PVC insulation.
3. Unshielded.
4. PVC jacket.
5. Flame Resistance: Comply with UL 1581.

B. Plenum-Rated Cable: NFPA 70, Type CMP.

1. Paired, two pairs, No. 22 AWG, stranded (7x30) tinned-copper conductors.
2. Fluorinated ethylene propylene insulation.
3. Unshielded.
4. Fluorinated ethylene propylene jacket.
5. Flame Resistance: NFPA 262, Flame Test.

2.5 LOW-VOLTAGE CONTROL CABLE

A. Paired Cable: NFPA 70, Type CMG.

1. One pair, twisted, No. 16 AWG, stranded (19x29) tinned-copper conductors.
2. PVC insulation.
3. Unshielded.
4. PVC jacket.
5. Flame Resistance: Comply with UL 1581.

B. Plenum-Rated, Paired Cable: NFPA 70, Type CMP.

1. One pair, twisted, No. 16 AWG, stranded (19x29) tinned-copper conductors.
2. PVC insulation.
3. Unshielded.
4. PVC jacket.
5. Flame Resistance: Comply with NFPA 262.

C. Paired Cable: NFPA 70, Type CMG.

1. One pair, twisted, No. 18 AWG, stranded (19x30) tinned-copper conductors.

2. PVC insulation.
3. Unshielded.
4. PVC jacket.
5. Flame Resistance: Comply with UL 1581.

D. Plenum-Rated, Paired Cable: NFPA 70, Type CMP.

1. One pair, twisted, No. 18 AWG, stranded (19x30) tinned-copper conductors.
2. Fluorinated ethylene propylene insulation.
3. Unshielded.
4. Plastic jacket.
5. Flame Resistance: NFPA 262, Flame Test.

2.6 CONTROL-CIRCUIT CONDUCTORS

A. Class 1 Control Circuits: Stranded copper, Type THHN-THWN, in raceway, complying with UL 83.

B. Class 2 Control Circuits: Stranded copper, Type THHN-THWN, in raceway, complying with UL 83.

C. Class 3 Remote-Control and Signal Circuits: Stranded copper, Type TW or Type TF, complying with UL 83.

2.7 IDENTIFICATION PRODUCTS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Brady Corporation.
2. Panduit Corp.
3. Or Approved Equal.

B. Comply with UL 969 for a system of labeling materials, including label stocks, laminating adhesives, and inks used by label printers.

C. Comply with requirements in Section 260553 "Identification for Electrical Systems."

PART 3 - EXECUTION

3.1 INSTALLATION OF PATHWAYS

A. Comply with TIA/EIA-569-A for pull-box sizing and length of conduit and number of bends between pull points.

B. Comply with requirements in Section 260533 "Raceways and Boxes for Electrical Systems" for installation of conduits and wireways.

C. Install manufactured conduit sweeps and long-radius elbows if possible.

D. Pathway Installation in Equipment Rooms:

1. Position conduit ends adjacent to a corner on backboard if a single piece of plywood is installed or in the corner of room if multiple sheets of plywood are installed around perimeter walls of room.
2. Install cable trays to route cables if conduits cannot be located in these positions.
3. Secure conduits to backboard if entering room from overhead.
4. Extend conduits 3 inches above finished floor.
5. Install metal conduits with grounding bushings and connect with grounding conductor to grounding system.

E. Backboards: Install backboards with 96-inch dimension vertical. Butt adjacent sheets tightly and form smooth gap-free corners and joints.

3.2 INSTALLATION OF CONDUCTORS AND CABLES

A. Comply with NECA 1.

B. General Requirements for Cabling:

1. Comply with TIA/EIA-568-B.1.
2. Comply with BICSI ITSIM, Ch. 6, "Cable Termination Practices."
3. Terminate all conductors; no cable shall contain unterminated elements. Make terminations only at indicated outlets, terminals, and cross-connect and patch panels.
4. Cables may not be spliced. Secure and support cables at intervals not exceeding 30 inches and not more than 6 inches from cabinets, boxes, fittings, outlets, racks, frames, and terminals.
5. Bundle, lace, and train conductors to terminal points without exceeding manufacturer's limitations on bending radii, but not less than radii specified in BICSI ITSIM, "Cabling Termination Practices" Chapter. Install lacing bars and distribution spools.
6. Do not install bruised, kinked, scored, deformed, or abraded cable. Do not splice cable between termination, tap, or junction points. Remove and discard cable if damaged during installation and replace it with new cable.
7. Cold-Weather Installation: Bring cable to room temperature before dereeling. Heat lamps shall not be used for heating.
8. Pulling Cable: Comply with BICSI ITSIM, Ch. 4, "Pulling Cable." Monitor cable pull tensions.

C. Installation of Control-Circuit Conductors:

1. Install wiring in raceways. Comply with requirements specified in Section 260533 "Raceways and Boxes for Electrical Systems."

D. Open-Cable Installation:

1. Install cabling with horizontal and vertical cable guides in telecommunications spaces with terminating hardware and interconnection equipment.

2. Suspend copper cable not in a wireway or pathway a minimum of 8 inches above ceilings by cable supports not more than 60 inches apart.
3. Cable shall not be run through structural members or in contact with pipes, ducts, or other potentially damaging items.

E. Separation from EMI Sources:

1. Comply with BICSI TDMM and TIA/EIA-569-A recommendations for separating unshielded copper voice and data communication cable from potential EMI sources, including electrical power lines and equipment.
2. Separation between open communications cables or cables in nonmetallic raceways and unshielded power conductors and electrical equipment shall be as follows:

   a. Electrical Equipment Rating Less Than 2 kVA: A minimum of 12 inches.
   b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 24 inches.
   c. Electrical Equipment Rating More Than 5 kVA: A minimum of 48 inches.

3. Separation between communications cables in grounded metallic raceways and unshielded power lines or electrical equipment shall be as follows:

   a. Electrical Equipment Rating Less Than 2 kVA: A minimum of 6 inches.
   b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 12 inches.
   c. Electrical Equipment Rating More Than 5 kVA: A minimum of 24 inches.

4. Separation between communications cables in grounded metallic raceways and power lines and electrical equipment located in grounded metallic conduits or enclosures shall be as follows:

   a. Electrical Equipment Rating Less Than 2 kVA: 3 inches.
   b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 6 inches.
   c. Electrical Equipment Rating More Than 5 kVA: A minimum of 12 inches.

5. Separation between Cables and Electrical Motors and Transformers: A minimum of 48 inches.
6. Separation between Cables and Fluorescent Fixtures: A minimum of 6 inches.

3.3 REMOVAL OF CONDUCTORS AND CABLES

A. Remove abandoned conductors and cables.

3.4 CONTROL-CIRCUIT CONDUCTORS

A. Minimum Conductor Sizes:

1. Class 1 remote-control and signal circuits, No. 14 AWG.
2. Class 2 low-energy, remote-control, and signal circuits, No. 16 AWG.
3. Class 3 low-energy, remote-control, alarm, and signal circuits, No 12 AWG.

3.5 FIRESTOPPING

A. Comply with requirements in Section 078413 "Penetration Firestopping."

B. Comply with TIA/EIA-569-A, Annex A, "Firestopping."

C. Comply with BICSI TDMM, "Firestopping Systems" Article.

3.6 GROUNDING

A. For data communications wiring, comply with ANSI-J-STD-607-A and with BICSI TDMM, "Grounding, Bonding, and Electrical Protection" Chapter.

B. For low-voltage wiring and cabling, comply with requirements in Section 260526 "Grounding and Bonding for Electrical Systems."

3.7 IDENTIFICATION

A. Identify system components, wiring, and cabling according to TIA/EIA-606-A. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

3.8 FIELD QUALITY CONTROL

A. Tests and Inspections:

1. Visually inspect cable placement, cable termination, grounding and bonding, equipment and patch cords, and labeling of all components.

B. Document data for each measurement. Print data for submittals in a summary report that is formatted using Table 10.1 in BICSI TDMM as a guide, or transfer the data from the instrument to the computer, save as text files, print, and submit.

C. End-to-end cabling will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

END OF SECTION 260523

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SECTION 260526 - GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes: Grounding systems and equipment.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product indicated.

1.3 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

1.4 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Comply with UL 467 for grounding and bonding materials and equipment.

PART 2 - PRODUCTS

2.1 CONDUCTORS

A. Insulated Conductors: Tinned-copper wire or cable insulated for 600 V unless otherwise required by applicable Code or authorities having jurisdiction.

B. Bare Copper Conductors:

1. Stranded Conductors: ASTM B 8.
2. Tinned Conductors: ASTM B 33.
3. Bonding Cable: 28 kcmil, 14 strands of No. 17 AWG conductor, 1/4 inch in diameter.
4. Bonding Conductor: No. 4 or No. 6 AWG, stranded conductor.
5. Bonding Jumper: Copper tape, braided conductors terminated with copper ferrules; 1-5/8 inches wide and 1/16 inch thick.
6. Tinned Bonding Jumper: Tinned-copper tape, braided conductors terminated with copper ferrules; 1-5/8 inches wide and 1/16 inch thick.

2.2 CONNECTORS

A. Listed and labeled by an NRTL acceptable to authorities having jurisdiction for applications in which used and for specific types, sizes, and combinations of conductors and other items connected.

B. Bolted Connectors for Conductors and Pipes: Copper or copper alloy, pressure type with at least two bolts.

1. Pipe Connectors: Clamp type, sized for pipe.

C. Welded Connectors: Exothermic-welding kits of types recommended by kit manufacturer for materials being joined and installation conditions.

2.3 GROUNDING ELECTRODES

A. Ground Rods: Copper-clad; 3/4 inch in diameter and 10 feet long.

PART 3 - EXECUTION

3.1 APPLICATIONS

A. Conductors: Install stranded conductors all conductor sizes.

B. Underground Grounding Conductors: Install bare tinned-copper conductor, No. 4/0 AWG minimum. Bury at least 24 inches below grade.

C. Isolated Grounding Conductors: Green-colored insulation with continuous yellow stripe. On feeders with isolated ground, identify grounding conductor where visible to normal inspection, with alternating bands of green and yellow tape, with at least three bands of green and two bands of yellow.

D. Conductor Terminations and Connections:

1. Pipe and Equipment Grounding Conductor Terminations: Bolted connectors.
2. Underground Connections: Welded or approved compression connectors except at test wells and as otherwise indicated.
3. Connections to Ground Rods at Test Wells: Bolted connectors.
4. Connections to Structural Steel: Welded connectors.

3.2 EQUIPMENT GROUNDING

A. Install insulated equipment grounding conductors with the following items, in addition to those required by NFPA 70:

1. Feeders and branch circuits.
2. Lighting circuits.
3. Receptacle circuits.

4. Single-phase motor and appliance branch circuits.
5. Three-phase motor and appliance branch circuits.
6. Flexible raceway runs.
7. Armored and metal-clad cable runs.
8. Busway Supply Circuits: Install insulated equipment grounding conductor from grounding bus in the switchgear, switchboard, or distribution panel to equipment grounding bar terminal on busway.
9. Computer and Rack-Mounted Electronic Equipment Circuits: Install insulated equipment grounding conductor in branch-circuit runs from equipment-area power panels and power-distribution units.
10. X-Ray Equipment Circuits: Install insulated equipment grounding conductor in circuits supplying x-ray equipment.

B. Air-Duct Equipment Circuits: Install insulated equipment grounding conductor to duct-mounted electrical devices operating at 120 V and more, including air cleaners, heaters, dampers, humidifiers, and other duct electrical equipment. Bond conductor to each unit and to air duct and connected metallic piping.

C. Water Heater, Heat-Tracing, and Antifrost Heating Cables: Install a separate insulated equipment grounding conductor to each electric water heater and heat-tracing cable. Bond conductor to heater units, piping, connected equipment, and components.

D. Signal and Communication Equipment: In addition to grounding and bonding required by NFPA 70, provide a separate grounding system complying with requirements in TIA/ATIS J-STD-607-A.

1. For telephone, alarm, voice and data, and other communication equipment, provide No. 4 AWG minimum insulated grounding conductor in raceway from grounding electrode system to each service location, terminal cabinet, wiring closet, and central equipment location.
2. Service and Central Equipment Locations and Wiring Closets: Terminate grounding conductor on a 1/4-by-4-by-12-inch grounding bus.
3. Terminal Cabinets: Terminate grounding conductor on cabinet grounding terminal.

E. Poles Supporting Outdoor Lighting Fixtures: Install grounding electrode and a separate insulated equipment grounding conductor in addition to grounding conductor installed with branch-circuit conductors.

3.3 INSTALLATION

A. Grounding Conductors: Route along shortest and straightest paths possible unless otherwise indicated or required by Code. Avoid obstructing access or placing conductors where they may be subjected to strain, impact, or damage.

B. Ground Rods: Drive rods until tops are 2 inches below finished floor or final grade unless otherwise indicated.

1. Interconnect ground rods with grounding electrode conductor below grade and as otherwise indicated. Make connections without exposing steel or damaging coating if any.

2. For grounding electrode system, install at least three rods spaced at least one-rod length from each other and located at least the same distance from other grounding electrodes, and connect to the service grounding electrode conductor.

C. Test Wells: Ground rod driven through drilled hole in bottom of handhole. Handholes are specified in Section 260543 "Underground Ducts and Raceways for Electrical Systems", and shall be at least 12 inches deep, with cover.

1. Test Wells: Install at least two test wells for each service unless otherwise indicated. Install at the ground rods electrically closest to service entrance. Set top of test well flush with finished grade or floor.

D. Bonding Straps and Jumpers: Install in locations accessible for inspection and maintenance except where routed through short lengths of conduit.

1. Bonding to Structure: Bond straps directly to basic structure, taking care not to penetrate any adjacent parts.
2. Bonding to Equipment Mounted on Vibration Isolation Hangers and Supports: Install bonding so vibration is not transmitted to rigidly mounted equipment.
3. Use exothermic-welded connectors for outdoor locations; if a disconnect-type connection is required, use a bolted clamp.

E. Grounding and Bonding for Piping:

1. Metal Water Service Pipe: Install insulated copper grounding conductors, in conduit, from building's main service equipment, or grounding bus, to main metal water service entrances to building. Connect grounding conductors to main metal water service pipes; use a bolted clamp connector or bolt a lug-type connector to a pipe flange using one of the lug bolts of the flange. Where a dielectric main water fitting is installed, connect grounding conductor on street side of fitting. Bond metal grounding conductor conduit or sleeve to conductor at each end.
2. Water Meter Piping: Use braided-type bonding jumpers to electrically bypass water meters. Connect to pipe with a bolted connector.
3. Bond each aboveground portion of gas piping system downstream from equipment shutoff valve.

F. Bonding Interior Metal Ducts: Bond metal air ducts to equipment grounding conductors of associated fans, blowers, electric heaters, and air cleaners. Install bonding jumper to bond across flexible duct connections to achieve continuity.

3.4 LABELING

A. Comply with requirements in Section 260553 "Identification for Electrical Systems" for instruction signs. The label or its text shall be green.

B. Install labels at the telecommunications bonding conductor and grounding equalizer.

1. Label Text: "If this connector or cable is loose or if it must be removed for any reason, notify the facility manager."

3.5 FIELD QUALITY CONTROL

A. Perform the following tests and inspections and prepare test reports:

1. After installing grounding system but before permanent electrical circuits have been energized, test for compliance with requirements.
2. Inspect physical and mechanical condition. Verify tightness of accessible, bolted, electrical connections with a calibrated torque wrench according to manufacturer's written instructions.
3. Test completed grounding system at each location where a maximum ground-resistance level is specified, at service disconnect enclosure grounding terminal, and at ground test wells. Make tests at ground rods before any conductors are connected.

B. Report measured ground resistances that exceed the following values:

1. Power and Lighting Equipment or System with Capacity of 500 kVA and Less: 10 ohms.
2. Power and Lighting Equipment or System with Capacity of 500 to 1000 kVA: 5 ohms.
3. Power and Lighting Equipment or System with Capacity More Than 1000 kVA: 3 ohms.
4. Power Distribution Units or Panelboards Serving Electronic Equipment: 3 ohm(s).

C. Excessive Ground Resistance: If resistance to ground exceeds specified values, notify Engineer promptly and include recommendations to reduce ground resistance.

END OF SECTION 260526

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SECTION 260533 - RACEWAYS AND BOXES FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SCOPE OF WORK

A. Furnish and install conduits as required, and as shown on the Plans. Materials employed shall be as shown on the Plans.

1.2 SUBMITTALS

A. Submit product literature including manufacturer part number, model number, material, size, and specifications. Material shall not be installed until the Engineer has reviewed the submittal data.

B. If changes from the Plan are proposed, shop drawings shall be submitted for review and acceptance showing routing, conduit size, and number and size of wires in each conduit before installation of conduit and any related work.

C. Proposed routing of conduits buried under floor slabs-on-grade.

D. Identify conduit by tag number of equipment served or by circuit schedule number.

E. Proposed routing and details of construction including conduit and rebar embedded in floor slabs, columns, etc.

F. Proposed location and details of construction for openings in slabs and walls for raceway runs.

G. Refer to Section 260000 “General Electrical Requirements” for further submittal requirements.

1.3 REFERENCES

A. American National Standards Institute (ANSI): C80.1, Rigid Steel Conduit - Zinc-Coated.

B. National Electric Manufacturers Association (NEMA): RN-1, Polyvinyl-Chloride (PVC) Externally Coated Galvanized Rigid Steel Conduit.

C. Underwriters Laboratories Inc. (UL):

1. 1, Flexible Metal Conduit.
2. 6, Rigid Metal Conduit.
3. 360, Liquid-Tight Flexible Steel Conduit.
4. 467, Grounding and Bonding Equipment.
5. 514, Nonmetallic Outlet Boxes, Flush-Device Boxes and Covers.
6. 651, Schedule 40 and 80 Rigid PVC Conduit.
7. 870, Wireways, Auxiliary Gutters, and Associated Fittings.
8. 884, Underfloor Raceways and Fittings.

9. 886, Outlet Boxes and Fittings for Use in Hazardous (Classified) Locations.

PART 2 - PRODUCTS

2.1 RACEWAYS

A. Exposed conduits in an unclassified or non-hazardous area shall be Galvanized Rigid Steel (GRS) unless specifically indicated otherwise on the Plans. Conduits in corrosive, hazardous, or damp areas shall be PVC coated GRS unless otherwise indicated. Underground and/or concrete encased conduits shall be PVC, unless otherwise indicated. All conduits concealed in block walls or steel framing shall be EMT with compression fittings unless otherwise indicated. Set screw type fittings in EMT conduit will not be accepted. All wiring, except as otherwise noted, shall be in conduit. Conduit size shall not be less than the National Electrical Code (NEC) size required for the conductors therein and shall not be smaller than 3/4-inch. No underground conduit shall be less than one inch.

B. Condulets type fittings shall be Crouse-Hinds, Appleton, or equal with wedge nut covers. All condulets located outdoors, damp or wet locations shall be weather tight.

C. In unclassified areas, flexible conduit shall be grounding type, weatherproof, corrosion resistant, and watertight.

D. Couplings, connectors, and fittings shall be standard types specifically designed and manufactured for the purpose. They shall be installed to provide a firm mechanical assembly and electrical conductivity throughout. Conduit systems shall be water tight.

E. Expansion fittings shall be OZ type AX with jumper for exposed locations and type DX at structural expansion joints, Spring City, or equal. Conduits shall have expansion fittings in accordance with NEC.

F. The conduits and fittings shall be supported per NEC requirements as a minimum.

G. Sealing fittings shall be provided for classified areas per the NEC requirements in hazardous or corrosive areas. Fittings shall be poured after the final walk-thru unless otherwise directed in writing by the engineer.

2.2 GALVANIZED RIGID STEEL (GRS)

A. Conduits and couplings shall be hot-dipped galvanized with zinc coated threads and outer coating of zinc bichromate, in accordance with ANSI C80.1 standards, as manufactured by Jones & Laughlin Steel Corporation, Allied Tube & Conduit Corporation, Triangle PWC, or equal.

B. Steel conduit shall not be buried in earth without concrete encasement and additional corrosion protection. Instead buried steel conduit shall be PVC coated.

2.3 PVC COATED GALVANIZED RIGID STEEL (PVC-GRS)

A. PVC coated GRS conduit shall be installed where shown on the Plans or elsewhere specified and shall conform to NEMA RN-1 and ANSI C80.1 standards.

B. The zinc surface of the conduit shall remain intact and undisturbed on both the inside and the outside of the conduit throughout the preparation and application processing. A Polyvinyl Chloride (PVC) coating shall be bonded to the galvanized outer surface of the conduit. The bond between the PVC coating and the conduit surface shall be greater than the tensile strength of the plastic. The thickness of the PVC coating shall be a minimum of 0.040-inch (40 mil).

C. A loose coupling shall be furnished with each length of conduit. A PVC coating shall be bonded to the outer surface of the coupling and a PVC sleeve equal to the outside diameter of the uncoated conduit shall extend beyond both ends of the coupling approximately one pipe diameter or 1-1/2 inches, whichever is smaller. The wall thickness of the coating on the coupling and the sleeve shall be a minimum of 0.055-inch (55 mil).

D. A PVC coating shall be bonded to the inner and outer surface of all conduit bodies and fittings and a PVC sleeve shall extend from all hubs. The wall thickness of the coating on conduit bodies and fittings and the sleeve walls shall be identical to those on couplings in length and thickness. The covers on all conduit bodies shall be coated on both sides and shall be designed to be completely interchangeable. The inside of conduit bodies shall remain undisturbed in the processing.

E. Type 304 stainless steel screws shall be furnished and used to attach the cover to the conduit body. All coated material shall be installed and patched according to the manufacturer's recommended installation and patching instructions.

F. Conduit straps shall be PVC coated or stainless steel.

G. PVC coated conduits and fittings shall be as manufactured by Kor Kap Corporation, Occidental Coating Company, Rob-Roy, or equal.

H. PVC coated flexible conduits shall be liquid and vapor-tight and manufactured in accordance with UL 360 standards.

2.4 RIGID NONMETALLIC – PVC

A. Where specifically indicated on the Plans, or elsewhere specified, conduit may be high density Schedule 40, 90 degrees C, heavy-duty PVC. The conduit shall be manufactured from virgin polyvinyl chloride compound which meets ASTM D1784, NEMA TC-2, ANSI C33.91, and UL 651 standards. Smoke emissions shall be limited to less than 6 grams per 100 grams of material tested.

B. Where conduit concrete encasement is indicated on the Plans, conduit supports shall be installed at five-foot intervals. PVC conduit shall be manufactured by Carlon, Triangle Conduit & Cable, or equal.

2.5 LIQUIDTIGHT FLEXIBLE METAL CONDUIT

A. Liquidtight flexible metal conduit shall be liquid and vapor-tight, oil and ultraviolet ray resistant and manufactured in accordance with UL 360 standards. Liquidtight flexible metal conduit shall be formed of a continuous, spiral wound, galvanized steel core with an extruded PVC jacket. The PVC jacket shall be rated for high ambient heat applications, 90 degrees Celsius.

B. For corrosive locations, liquidtight flexible metal conduit shall be formed of a continuous, spiral wound, aluminum core with an extruded PVC jacket. The PVC jacket shall be impervious to corrosive liquids and vapors and PVC coated fittings shall be utilized.

C. An external bonding conductor shall be required for flexible conduit connections containing circuits rated at 60 amps or greater and for sizes 1 1/2 " or larger. Flexible conduits and connectors for 1 1/4 " and smaller shall be listed for grounding.

D. For non-corrosive locations, connectors for liquidtight flexible conduit shall be galvanized, furnished with a sealing ring and locknut, and suitable for wet locations. For corrosive locations, connectors shall be galvanized PVC coated.

2.6 ELECTRICAL METALLIC TUBING (EMT)

A. Per UL Standard for Electrical Metallic Tubing No. 797. Galvanized mild steel with interior coat of enamel.

B. Fittings shall be steel set-screw type. Cast type, indenter type or compression steel fittings are not acceptable.

C. Approved for plan specified locations only. Approved for conduits concealed in block walls and concealed in steel framed walls. Not approved for process areas where wash down or high humidity conditions exist.

2.7 ALUMINUM CONDUIT

A. Aluminum conduit is approved for wet and corrosive areas only. Prior approval from the engineer must be obtained when substituting for PVC coated.

B. Aluminum hardware and conduit shall be isolated from all dissimilar materials as appropriate.

1. Isolation from dissimilar metals in channel or support by a single layer of scotch #33+ or approved equal.
2. Isolation from concrete shall be by neoprene gaskets.
3. Aluminum shall not be used for concrete penetrations.

C. Aluminum conduit shall contain less than 0.4% copper.

2.8 STAINLESS STEEL CONDUIT

A. Stainless Steel Conduit conduit is approved for all exposed conduit locations. Prior approval from the engineer must be obtained when substituting for PVC coated.

B. Stainless Steel conduit and all fittings and support hardware shall be 316 SS.

2.9 CABLE TRAY SYSTEM

A. Provide cable tray systems composed of straight sections, fittings, and accessories as defined in the latest NEMA Standards publication VE-1 - Ventilated Cable Tray.

1. Provide cable trays and fittings shall constructed of materials suited for the area classification as noted below.
2. Provide cable trays shall be of the ladder type with availability of 6, 9, and 12-inch spacing.
3. Provide tray sizes with a 3, 4, 5, or 6-inch minimum usable load depth, as indicated on the drawings.
4. Provide loading capacities that meet the NEMA weight classification with a safety factor of 1.5.
5. In corrosive, damp, or Hazardous locations, provide cable trays manufactured of aluminum.
6. In non-classified areas provide cable trays manufactured of Hot Dipped galvanized materials. All cuts and welds shall be touched up with cold galvanizing spray per the raceway specification.
7. Separate power, control, signal and communications cables by grounded metallic dividers or run in separate trays.
8. Manufacturer, or Approved Equal

   a. Husky
   b. B-Line
   c. T.J. Cope

PART 3 - EXECUTION

3.1 INSTALLATION

A. Conduit runs are schematic only, and shall be modified as required to suit field conditions, subject to review and acceptance by the Engineer.

B. Conduit shall run continuously between outlets and shall be provided with junction boxes where connections are made. Couplings, connectors, and fittings shall be acceptable types designed and manufactured for the purpose, and shall provide a firm mechanical assembly, and electrical conductivity throughout.

C. Conduit runs shall be straight and true. Elbows, offsets, and bends shall be uniform and symmetrical. Changes in direction shall be made with long radius bends, or with fittings of the condulet type.

D. Conduit runs in buildings and structures shall be concealed where possible except as specifically noted, or accepted by the Engineer.

E. Conduit runs shall not interfere with the proper and safe operation of equipment, and shall not block or interfere with ingress or egress, including equipment removal hatches.

F. Exposed conduits shall be securely fastened with clamps, or straps, intended for conduit use. All exposed conduit shall be run on the walls and ceiling only and shall be parallel to the planes of the walls or ceiling. No diagonal runs will be permitted. Flexible conduit shall be used only for short lengths required to facilitate connections between rigid conduit to vibrating equipment such as motors, fans, and transformers. The maximum length of flexible conduit shall be 3 feet, unless approved in writing by engineer. Flexible conduit shall not be used for electrician's convenience where rigid conduit could be used.

G. Conduit runs on water-bearing walls shall be supported one inch away from the wall on an accepted channel. When channel galvanizing, or other coating, is cut or otherwise damaged, it shall be field coated to original condition. No conduit shall be run in water-bearing walls, unless specifically designated otherwise.

H. Conduit shall be thoroughly reamed to remove burrs. IMC or GRS shall be reamed during the threading process, and Rigid Nonmetallic PVC shall be reamed before applying fittings. A zinc rich cold galvanizing shall be used to restore corrosion protection on field cut threads.

I. Bushings and lock nuts or hubs shall be used at conduit terminations. Conduit, bushings, locknuts, and enclosures shall be fastened to the conduit system prior to pulling wire. Splitting the bushings for installation will not be accepted. Hubs shall be used in all process areas outside of electrical rooms unless otherwise specified. The total number of bends in any run between pull points shall not exceed 360 degrees. Junction boxes and pull boxes shall be installed at points acceptable to the Engineer. Conduit ends shall be plugged to prevent the entrance of moisture or debris during construction. All spare conduits shall be adequately capped and shall contain a suitable pull string. Splices shall be made in junction boxes only. Splices in conduit bodies will not be accepted.

J. Joints shall be set up tight. Hangers and fastenings shall be secure, and of a type appropriate in design, and dimensions, for the particular application.

K. Conduit runs shall be cleaned and internally sized (obstruction tested) so that no foreign objects, or obstructions remain in the conduit prior to pulling in conductors.

L. After installation of complete conduit runs 2 inches and larger, conduits shall be snaked with a conduit cleaner equipped with a cylindrical mandrel of a diameter not less than 85 percent of the nominal diameter of the conduit. Conduits through which the mandrel will not pass shall not be used. Test results should be submitted to the engineer.

M. Expansion fittings shall be installed across all expansion joints and at other locations where necessary to compensate for thermal expansion and contraction.

N. Provide trenching, backfill, and compaction for conduits installed underground.

O. Raceways running parallel to hot water or steam piping shall maintain a distance of 6 inches from the piping.

P. Raceways crossing steam or liquid filling piping shall cross above the piping.

Q. In slab conduits, shall be covered by a minimum of 2 inches of concrete.

R. Conduits of the same duty (480V Power, 120V Power, 120V Controls and signals) shall have a minimum separation of 2 inches between conduits.

S. Conduits and raceways carrying signal wiring shall have a minimum separation of 12 inches from 480V power raceways, 6 inches from 120V power raceways, and 4 inches from 120V control raceways.

T. Raceways with 120V Control shall maintain a distance of 12 inches from 480V power raceways, 6 inches from 120V power raceways.

U. Raceways with 120V power shall maintain a distance of 6 inches from 480V power raceways.

3.2 CABLE TRAYS

A. Provide cable trays in strict accordance with the manufacturer's printed instructions.

B. Allowable cable fill areas shall meet NEC Article 392 - Cable Trays requirements.

C. Verify cable tray fills prior to installation based on cables and trays actually provided.

D. Maintain continuous grounding of cable trays including bonding jumpers in accordance with the requirements of NEC Article 392.

E. Install cable trays using hangers and supports on 8-foot centers, maximum.

F. Install cable trays to walls as the primary method of support where possible.

G. If support from the ceiling is the only alternative, use hangers and supports on 6-foot centers, maximum.

H. Ensure that proper separation between duties as detailed in 3.1.

END OF SECTION 260533

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SECTION 260534 – ENCLOSURES

PART 1 - GENERAL

1.1 SCOPE OF WORK

A. This specification includes enclosures to house electrical controls, instruments, terminal blocks, and serve as junction boxes where shown on the Drawings.

1.2 RELATED SECTIONS

A. For Raceways and Boxes for Electrical Systems see Section 260533 “Raceways and Boxes for Electrical Systems”.

1.3 SUBMITTALS

A. Products shall be submitted in accordance with Section 26000 “General Electrical Requirements”, and elsewhere in the Contract Documents, prior to installation.

1.4 MANUFACTURERS

A. Enclosures shall be manufactured by Hoffman, Rittal, or equal.

PART 2 - PRODUCTS

2.1 STEEL

A. Enclosures shall be fabricated from 14 gauge steel with seams that are continuously welded. Doors shall have full length piano hinges with the door removable by pulling the hinge pin.

B. A rolled lip shall be provided around three sides of the door and around all sides of the enclosure opening. The gasket shall be attached with oil-resistant adhesive and held in place with steel retaining strips. Exterior hardware, such as clamps, screws, and hinge pins, shall be of stainless steel for outdoor installations. A hasp and staple shall be provided for padlocking. Each enclosure shall have a print pocket. All wires entering or leaving the enclosure shall terminate on terminal strips. All wires and terminals shall be clearly identified as specified elsewhere in these specifications.

C. Finish shall be white enamel interior, light gray enamel, ANSI 61 exterior, over phosphatized surfaces. Special finishes and colors shall be furnished for wet locations. Plans should be checked for special conditions.

2.2 NEMA RATING

A. Unless otherwise indicated on the Plans, enclosures shall be NEMA 12 for indoors, NEMA 4X for corrosive areas, and NEMA 4 for outdoor installations. NEMA 4X enclosures shall be stainless steel, unless noted otherwise. NEMA 4X enclosures shall also be used in wet, or wash down areas.

B. All enclosures used in classified areas shall be NEMA 7.

C. In Waste Water facilities, all enclosures in process areas shall be NEMA 4X stainless steel. Enclosures in electrical rooms, meeting rooms, offices and shops shall be NEMA 12 unless otherwise specified.

D. Areas not specified in Water Treatment, Wastewater, or other water related facilities shall be approved by the engineer for NEMA type prior to installation.

2.3 FIBERGLASS

A. Enclosures shall be heavy-duty, compression molded, fiberglass reinforced polyester, high impact, heat resistant, NEMA 4X.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Enclosures shall be installed as indicated on the Plans, and according to manufacturer's instructions.

B. Enclosures shall be properly grounded, and shall include ground straps connected to hinged doors and accessories.

END OF SECTION 260534

SECTION 260543 – UNDERGROUND DUCTS AND RACEWAYS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Conduit, ducts, and duct accessories for concrete-encased duct banks.
2. Handholes and boxes.
3. Manholes.

B. Related Requirements:

1. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 ACTION SUBMITTALS

A. Product Data: For accessories for handholes and boxes.

B. Shop Drawings for Factory-Fabricated Handholes and Boxes: Include dimensioned plans, sections, elevations, and fabrication and installation details, including the following:

1. Duct entry provisions, including locations and duct sizes.
2. Cover design.
3. Grounding details.
4. Dimensioned locations of cable rack inserts, and pulling-in and lifting irons.

1.3 INFORMATIONAL SUBMITTALS

A. Field quality-control test reports.

1.4 QUALITY ASSURANCE

A. Comply with ANSI C2.

B. Comply with NFPA 70.

PART 2 - PRODUCTS

2.1 CONDUIT

A. Rigid Steel Conduit: Galvanized. Comply with ANSI C80.1.

B. RNC: NEMA TC 2, Type EPC-40-PVC, UL 651, with matching fittings by same manufacturer as the conduit, complying with NEMA TC 3 and UL 514B.

2.2 NONMETALLIC DUCTS AND DUCT ACCESSORIES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. ARNCO Corp.
2. Beck Manufacturing.
3. Cantex, Inc.
4. CertainTeed Corp.; Pipe & Plastics Group.
5. Condux International, Inc.
6. ElecSys, Inc.
7. Electri-Flex Company.
8. IPEX Inc.
9. Lamson & Sessions; Carlon Electrical Products.
10. Manhattan/CDT; a division of Cable Design Technologies.
11. Spiraduct/AFC Cable Systems, Inc.

B. Underground Plastic Utilities Duct: NEMA TC 2, Type EPC-40-PVC, UL 651, with matching fittings by the same manufacturer as the conduit, complying with NEMA TC 3 and UL 514B.

C. Duct Accessories:

1. Duct Separators: Factory-fabricated rigid PVC interlocking spacers, sized for type and sizes of ducts with which used, and selected to provide minimum duct spacings indicated while supporting ducts during concreting or backfilling.
2. Warning Tape: Underground-line warning tape specified in Section 260553 "Identification for Electrical Systems."
3. Concrete Warning Planks: Nominal 12 by 24 by 3 inches (300 by 600 by 76 mm) in size, manufactured from 6000-psi (41-MPa) concrete.

    a. Color: Red dye added to concrete during batching.
    b. Mark each plank with "ELECTRIC" in 2-inch- (50-mm-) high, 3/8-inch- (10-mm-) deep letters.

2.3 HANDHOLES AND BOXES

A. Description: Comply with SCTE 77.

1. Color: Gray or Green, depending on location.

2. Configuration: Units shall be designed for flush burial and have open bottom, unless otherwise indicated.
3. Cover: Weatherproof, secured by tamper-resistant locking devices and having structural load rating consistent with enclosure.
4. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.
5. Cover Legend: Molded lettering, "ELECTRIC."
6. Handholes 12 inches wide by 24 inches long and larger shall have inserts for cable racks and pulling-in irons installed before concrete is poured.

B. Fiberglass Handholes and Boxes with Polymer Concrete Frame and Cover: Sheet-molded, fiberglass-reinforced, polyester resin enclosure joined to polymer concrete top ring or frame.

1. Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawings or a comparable product by one of the following:

a. Armorcast Products Company.
b. Carson Industries LLC.
c. Christy Concrete Products.
d. Synertech Moulded Products, Inc.; a division of Oldcastle Precast.

PART 3 - EXECUTION

3.1 EARTHWORK

A. Excavation and Backfill: Comply with Section 312000 "General Earthwork," but do not use heavy-duty, hydraulic-operated, compaction equipment.

B. Restore surface features at areas disturbed by excavation and reestablish original grades, unless otherwise indicated. Replace removed sod immediately after backfilling is completed.

C. Cut and patch existing pavement in the path of underground ducts and utility structures.

3.2 DUCT INSTALLATION

A. Slope: Pitch ducts a minimum slope of 1:300 down toward handholes and away from buildings and equipment.

B. Curves and Bends: Use 5-degree angle couplings for small changes in direction. Use manufactured long sweep bends with a minimum radius of 48 inches, both horizontally and vertically, at other locations, unless otherwise indicated.

C. Joints: Use solvent-cemented joints in ducts and fittings and make watertight according to manufacturer's written instructions. Stagger couplings so those of adjacent ducts do not lie in same plane.

D. Duct Entrances to Concrete and Polymer Concrete Handholes: Use end bells, spaced approximately 10 inches (250 mm) o.c. for 5-inch (125-mm) ducts, and vary proportionately for other duct sizes.

1. Begin change from regular spacing to end-bell spacing 10 feet (3 m) from the end bell without reducing duct line slope and without forming a trap in the line.
2. Direct-Buried Duct Banks: Install an expansion and deflection fitting in each conduit in the area of disturbed earth adjacent to handhole.
3. Grout end bells into structure walls from both sides to provide watertight entrances.

E. Building Wall Penetrations: Make a transition from underground duct to rigid steel conduit at least 10 feet (3 m) outside the building wall without reducing duct line slope away from the building, and without forming a trap in the line. Use fittings manufactured for duct-to-conduit transition. Install conduit penetrations of building walls as specified in Section 260544 "Sleeves and Sleeve Seals for Electrical Raceways and Cabling."

F. Sealing: Provide temporary closure at terminations of ducts that have cables pulled. Seal spare ducts at terminations. Use sealing compound and plugs to withstand at least 15-psig (1.03-MPa) hydrostatic pressure.

G. Pulling Cord: Install 100-lbf- (445-N-) test nylon cord in ducts, including spares.

H. Concrete-Encased Ducts: Support ducts on duct separators.

1. Separator Installation: Space separators close enough to prevent sagging and deforming of ducts, with not less than 5 spacers per 20 feet (6 m) of duct. Secure separators to earth and to ducts to prevent floating during concreting. Stagger separators approximately 6 inches (150 mm) between tiers. Tie entire assembly together using fabric straps; do not use tie wires or reinforcing steel that may form conductive or magnetic loops around ducts or duct groups.
2. Concreting Sequence: Pour each run of envelope between terminations in one continuous operation.

   a. Start at one end and finish at the other, allowing for expansion and contraction of ducts as their temperature changes during and after the pour. Use expansion fittings installed according to manufacturer's written recommendations, or use other specific measures to prevent expansion-contraction damage.
   b. If more than one pour is necessary, terminate each pour in a vertical plane and install 3/4-inch (19-mm) reinforcing rod dowels extending 18 inches (450 mm) into concrete on both sides of joint near corners of envelope.

3. Pouring Concrete: Spade concrete carefully during pours to prevent voids under and between conduits and at exterior surface of envelope. Do not allow a heavy mass of concrete to fall directly onto ducts. Use a plank to direct concrete down sides of bank assembly to trench bottom. Allow concrete to flow to center of bank and rise up in middle, uniformly filling all open spaces. Do not use power-driven agitating equipment unless specifically designed for duct-bank application.
4. Reinforcement: Reinforce concrete-encased duct banks where they cross disturbed earth and where indicated. Arrange reinforcing rods and ties without forming conductive or magnetic loops around ducts or duct groups.
5. Forms: Use walls of trench to form side walls of duct bank where soil is self-supporting and concrete envelope can be poured without soil inclusions; otherwise, use forms.
6. Minimum Space between Ducts: 3 inches between ducts and exterior envelope wall, 3 inches between ducts for like services, and 6 inches between power and signal ducts.

7. Depth: Install top of duct bank at least 24 inches below finished grade in areas not subject to deliberate traffic, and at least 24 inches below finished grade in deliberate traffic paths for vehicles, unless otherwise indicated.
8. Stub-Ups: Use manufactured duct elbows for stub-ups at poles and equipment and at building entrances through the floor, unless otherwise indicated. Extend concrete encasement throughout the length of the elbow.
9. Stub-Ups: Use manufactured rigid steel conduit elbows for stub-ups at poles and equipment and at building entrances through the floor.

    a. Couple steel conduits to ducts with adapters designed for this purpose, and encase coupling with 3 inches of concrete.
    b. Stub-Ups to Equipment: For equipment mounted on outdoor concrete bases, extend steel conduit horizontally a minimum of 60 inches from edge of base. Install insulated grounding bushings on terminations at equipment.

10. Warning Tape: Bury warning tape approximately 12 inches above all concrete-encased ducts and duct banks. Align tape parallel to and within 3 inches of the centerline of duct bank. Provide an additional warning tape for each 12-inch increment of duct-bank width over a nominal 18 inches. Space additional tapes 12 inches apart, horizontally.

I. Direct-Buried Duct Banks:

1. Support ducts on duct separators coordinated with duct size, duct spacing, and outdoor temperature.
2. Space separators close enough to prevent sagging and deforming of ducts, with not less than 5 spacers per 20 feet of duct. Secure separators to earth and to ducts to prevent displacement during backfill and yet permit linear duct movement due to expansion and contraction as temperature changes. Stagger spacers approximately 6 inches between tiers.
3. Excavate trench bottom to provide firm and uniform support for duct bank. Prepare trench bottoms as specified in Section 312000 "General Earthwork" for pipes less than 6 inches in nominal diameter.
4. Install backfill as specified in Section 312000 " General Earthwork."
5. After installing first tier of ducts, backfill and compact. Start at tie-in point and work toward end of duct run, leaving ducts at end of run free to move with expansion and contraction as temperature changes during this process. Repeat procedure after placing each tier. After placing last tier, hand-place backfill to 4 inches over ducts and hand tamp. Firmly tamp backfill around ducts to provide maximum supporting strength. Use hand tamper only. After placing controlled backfill over final tier, make final duct connections at end of run and complete backfilling with normal compaction as specified in Section 312000 " General Earthwork."
6. Install ducts with a minimum of 3 inches between ducts for like services and 6 inches between power and signal ducts.
7. Depth: Install top of duct bank at least 24 inches below finished grade, unless otherwise indicated.
8. Set elevation of bottom of duct bank below the frost line.
9. Install manufactured duct elbows for stub-ups at poles and equipment and at building entrances through the floor, unless otherwise indicated. Encase elbows for stub-up ducts throughout the length of the elbow.
10. Install manufactured rigid steel conduit elbows for stub-ups at poles and equipment and at building entrances through the floor.

a. Couple steel conduits to ducts with adapters designed for this purpose, and encase coupling with 3 inches of concrete.
b. For equipment mounted on outdoor concrete bases, extend steel conduit horizontally a minimum of 60 inches from edge of equipment pad or foundation. Install insulated grounding bushings on terminations at equipment.

11. Warning Planks: Bury warning planks approximately 12 inches above direct-buried ducts and duct banks, placing them 24 inches o.c. Align planks along the width and along the centerline of duct bank. Provide an additional plank for each 12-inch increment of ductbank width over a nominal 18 inches. Space additional planks 12 inches apart, horizontally.

3.3 INSTALLATION OF HANDHOLES AND BOXES OTHER THAN PRECAST CONCRETE

A. Install handholes and boxes level and plumb and with orientation and depth coordinated with connecting ducts to minimize bends and deflections required for proper entrances. Use box extension if required to match depths of ducts, and seal joint between box and extension as recommended by the manufacturer.

B. Unless otherwise indicated, support units on a level bed of crushed stone or gravel, graded from 1/2-inch (12.7-mm) sieve to No. 4 (4.75-mm) sieve and compacted to same density as adjacent undisturbed earth.

C. Elevation: In paved areas and trafficways, set so cover surface will be flush with finished grade. Set covers of other handholes 1 inch (25 mm) above finished grade.

D. Install handholes and boxes with bottom below the frost line.

E. Install removable hardware, including pulling eyes, cable stanchions, cable arms, and insulators, as required for installation and support of cables and conductors and as indicated. Select arm lengths to be long enough to provide spare space for future cables, but short enough to preserve adequate working clearances in the enclosure.

F. Field-cut openings for ducts and conduits according to enclosure manufacturer's written instructions. Cut wall of enclosure with a tool designed for material to be cut. Size holes for terminating fittings to be used, and seal around penetrations after fittings are installed.

3.4 GROUNDING

A. Ground underground ducts and utility structures according to Section 260526 "Grounding and Bonding for Electrical Systems."

3.5 FIELD QUALITY CONTROL

A. Perform the following field tests and inspections and prepare test reports:

1. Demonstrate capability and compliance with requirements on completion of installation of underground ducts and utility structures.

2. Pull aluminum or wood test mandrel through duct to prove joint integrity and test for out-of-round duct. Provide mandrel equal to 80 percent fill of duct. If obstructions are indicated, remove obstructions and retest.
3. Test handhole grounding to ensure electrical continuity of grounding and bonding connections. Measure and report ground resistance as specified in Section 260526 "Grounding and Bonding for Electrical Systems."

B. Correct deficiencies and retest as specified above to demonstrate compliance.

3.6 CLEANING

A. Pull leather-washer-type duct cleaner, with graduated washer sizes, through full length of ducts. Follow with rubber duct swab for final cleaning and to assist in spreading lubricant throughout ducts.

END OF SECTION 260543

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SECTION 260548 - VIBRATION AND SEISMIC CONTROLS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes:
1. Channel support systems.
2. Restraint cables.
3. Hanger rod stiffeners.
4. Anchorage bushings and washers.

1.2 PERFORMANCE REQUIREMENTS

A. Seismic-Restraint Loading:

1. Site class, building code and Design Spectral Response Acceleration as defined on the Contract Drawings.

1.3 ACTION SUBMITTALS

A. Product Data: For the following:

1. Include rated load, rated deflection, and overload capacity for each vibration isolation device.
2. Illustrate and indicate style, material, strength, fastening provision, and finish for each type and size of seismic-restraint component used.

a. Tabulate types and sizes of seismic restraints, complete with report numbers and rated strength in tension and shear as evaluated by an agency acceptable to authorities having jurisdiction.
b. Annotate to indicate application of each product submitted and compliance with requirements.

3. Restrained-Isolation Devices: Include ratings for horizontal, vertical, and combined loads.

B. Delegated-Design Submittal: For seismic-restraint details indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1. Design Calculations: Calculate static and dynamic loading due to equipment weight and operation, seismic forces required to select vibration isolators and seismic restraints.

a. Coordinate design calculations with wind-load calculations required for equipment mounted outdoors. Comply with requirements in other electrical Sections for equipment mounted outdoors.

2. Indicate materials and dimensions and identify hardware, including attachment and anchorage devices.
3. Field-fabricated supports.
4. Seismic-Restraint Details:

   a. Design Analysis: To support selection and arrangement of seismic restraints. Include calculations of combined tensile and shear loads.
   b. Details: Indicate fabrication and arrangement. Detail attachments of restraints to the restrained items and to the structure. Show attachment locations, methods, and spacings. Identify components, list their strengths, and indicate directions and values of forces transmitted to the structure during seismic events.
   c. Preapproval and Evaluation Documentation: By an agency acceptable to authorities having jurisdiction, showing maximum ratings of restraint items and the basis for approval (tests or calculations).

1.4 INFORMATIONAL SUBMITTALS

A. Welding certificates.

B. Field quality-control test reports.

1.5 QUALITY ASSURANCE

A. Comply with seismic-restraint requirements in the IBC unless requirements in this Section are more stringent.

B. Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."

C. Seismic-restraint devices shall have horizontal and vertical load testing and analysis and shall bear anchorage preapproval OPA number from OSHPD, preapproval by ICC-ES, or preapproval by another agency acceptable to authorities having jurisdiction, showing maximum seismic-restraint ratings. Ratings based on independent testing are preferred to ratings based on calculations. If preapproved ratings are not available, submittals based on independent testing are preferred. Calculations (including combining shear and tensile loads) to support seismic-restraint designs must be signed and sealed by a qualified professional engineer.

D. Comply with NFPA 70.

PART 2 - PRODUCTS

2.1 SEISMIC-RESTRAINT DEVICES

A. Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

   1. Amber/Booth Company, Inc.

2. California Dynamics Corporation.
3. Cooper B-Line, Inc.; a division of Cooper Industries.
4. Hilti Inc.
5. Loos & Co.; Seismic Earthquake Division.
6. Mason Industries.
7. TOLCO Incorporated; a brand of NIBCO INC.
8. Unistrut; Tyco International, Ltd.

B. General Requirements for Restraint Components: Rated strengths, features, and application requirements shall be as defined in reports by an agency acceptable to authorities having jurisdiction.

1. Structural Safety Factor: Allowable strength in tension, shear, and pullout force of components shall be at least four times the maximum seismic forces to which they will be subjected.

C. Channel Support System: MFMA-3, shop- or field-fabricated support assembly made of slotted steel channels with accessories for attachment to braced component at one end and to building structure at the other end and other matching components and with corrosion-resistant coating; and rated in tension, compression, and torsion forces.

D. Hanger Rod Stiffener: Reinforcing steel angle clamped to hanger rod. Do not weld stiffeners to rods.

E. Bushings for Floor-Mounted Equipment Anchor: Neoprene bushings designed for rigid equipment mountings, and matched to type and size of anchors and studs.

F. Bushing Assemblies for Wall-Mounted Equipment Anchorage: Assemblies of neoprene elements and steel sleeves designed for rigid equipment mountings, and matched to type and size of attachment devices.

G. Resilient Isolation Washers and Bushings: One-piece, molded, oil- and water-resistant neoprene, with a flat washer face.

H. Mechanical Anchor: Drilled-in and stud-wedge or female-wedge type in zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchors with strength required for anchor and as tested according to ASTM E 488. Minimum length of eight times diameter.

I. Adhesive Anchor: Drilled-in and capsule anchor system containing polyvinyl or urethane methacrylate-based resin and accelerator, or injected polymer or hybrid mortar adhesive. Provide anchor bolts and hardware with zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchor bolts with strength required for anchor and as tested according to ASTM E 488.

PART 3 - EXECUTION

3.1 APPLICATIONS

A. Multiple Raceways or Cables: Secure raceways and cables to trapeze member with clamps approved for application by an agency acceptable to authorities having jurisdiction.

B. Hanger Rod Stiffeners: Install hanger rod stiffeners where indicated or scheduled on Drawings to receive them and where required to prevent buckling of hanger rods due to seismic forces.

C. Strength of Support and Seismic-Restraint Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static and seismic loads within specified loading limits.

3.2 SEISMIC-RESTRAINT DEVICE INSTALLATION

A. Equipment and Hanger Restraints:

1. Install restrained isolators on electrical equipment.
2. Install resilient, bolt-isolation washers on equipment anchor bolts where clearance between anchor and adjacent surface exceeds 0.125 inch (3.2 mm).
3. Install seismic-restraint devices using methods approved by an agency acceptable to authorities having jurisdiction providing required submittals for component.

B. Install bushing assemblies for mounting bolts for wall-mounted equipment, arranged to provide resilient media where equipment or equipment-mounting channels are attached to wall.

C. Attachment to Structure: If specific attachment is not indicated, anchor bracing to structure at flanges of beams, at upper truss chords of bar joists, or at concrete members.

D. Drilled-in Anchors:

1. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcing or embedded items during coring or drilling. Notify the structural engineer if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid prestressed tendons, electrical and telecommunications conduit, and gas lines.
2. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.
3. Wedge Anchors: Protect threads from damage during anchor installation. Heavy-duty sleeve anchors shall be installed with sleeve fully engaged in the structural element to which anchor is to be fastened.
4. Adhesive Anchors: Clean holes to remove loose material and drilling dust prior to installation of adhesive. Place adhesive in holes proceeding from the bottom of the hole and progressing toward the surface in such a manner as to avoid introduction of air pockets in the adhesive.
5. Set anchors to manufacturer's recommended torque, using a torque wrench.
6. Install zinc-coated steel anchors for interior and stainless-steel anchors for exterior applications.

3.3 ACCOMMODATION OF DIFFERENTIAL SEISMIC MOTION

A. Install flexible connections in runs of raceways, cables, wireways, cable trays, and busways where they cross seismic joints, where adjacent sections or branches are supported by different structural elements, and where they terminate with connection to equipment that is anchored to a different structural element from the one supporting them as they approach equipment.

3.4 FIELD QUALITY CONTROL

A. Tests and Inspections:

1. Obtain Engineer's approval before transmitting test loads to structure. Provide temporary load-spreading members.
2. Test at least four of each type and size of installed anchors and fasteners selected by Engineer.
3. Test to 90 percent of rated proof load of device.
4. If a device fails test, modify all installations of same type and retest until satisfactory results are achieved.

B. Remove and replace malfunctioning units and retest as specified above.

C. Prepare test and inspection reports.

3.5 ADJUSTING

A. Adjust isolators after isolated equipment is at operating weight.

B. Adjust limit stops on restrained spring isolators to mount equipment at normal operating height. After equipment installation is complete, adjust limit stops so they are out of contact during normal operation.

C. Adjust active height of spring isolators.

D. Adjust restraints to permit free movement of equipment within normal mode of operation.

END OF SECTION 260548

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SECTION 260553 - IDENTIFICATION FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Identification for raceways.
2. Identification of power and control cables.
3. Identification for conductors.
4. Underground-line warning tape.
5. Warning labels and signs.
6. Instruction signs.
7. Equipment identification labels.
8. Miscellaneous identification products.

1.2 ACTION SUBMITTALS

A. Product Data: For each electrical identification product indicated.

B. Samples of each color, lettering style and other graphic representation required for each identification material or system.

C. Table or list of equipment, panel and disconnect switch labels.

1.3 QUALITY ASSURANCE

A. Comply with ANSI A13.1.

B. Comply with NFPA 70.

C. Comply with 29 CFR 1910.144 and 29 CFR 1910.145.

D. Comply with ANSI Z535.4 for safety signs and labels.

E. Adhesive-attached labeling materials, including label stocks, laminating adhesives, and inks used by label printers, shall comply with UL 969.

PART 2 - PRODUCTS

2.1 POWER RACEWAY IDENTIFICATION MATERIALS

A. Comply with ANSI A13.1 for minimum size of letters for legend and for minimum length of color field for each raceway size.

B. Colors for Raceways Carrying Circuits at 600 V or Less:

1. Black letters on an orange field.
2. Legend: Indicate voltage and system or service type.

C. Self-Adhesive Vinyl Labels for Raceways Carrying Circuits at 600 V or Less: Preprinted, flexible label laminated with a clear, weather- and chemical-resistant coating and matching wraparound adhesive tape for securing ends of legend label.

D. Snap-Around Labels for Raceways Carrying Circuits at 600 V or Less: Slit, pretensioned, flexible, preprinted, color-coded acrylic sleeve, with diameter sized to suit diameter of raceway or cable it identifies and to stay in place by gripping action.

E. Snap-Around, Color-Coding Bands for Raceways Carrying Circuits at 600 V or Less: Slit, pretensioned, flexible, solid-colored acrylic sleeve, 2 inches long, with diameter sized to suit diameter of raceway or cable it identifies and to stay in place by gripping action.

F. Write-On Tags shall not be allowed.

2.2 ARMORED AND METAL-CLAD CABLE IDENTIFICATION MATERIALS

A. Comply with ANSI A13.1 for minimum size of letters for legend and for minimum length of color field for each raceway and cable size.

B. Colors for Raceways Carrying Circuits at 600 V and Less:

1. Black letters on an orange field.
2. Legend: Indicate voltage and system or service type.

C. Self-Adhesive Vinyl Labels: Preprinted, flexible label laminated with a clear, weather- and chemical-resistant coating and matching wraparound adhesive tape for securing ends of legend label.

D. Self-Adhesive Vinyl Tape: Colored, heavy duty, waterproof, fade resistant; 2 inches wide; compounded for outdoor use.

2.3 POWER AND CONTROL CABLE IDENTIFICATION MATERIALS

A. Comply with ANSI A13.1 for minimum size of letters for legend and for minimum length of color field for each raceway and cable size.

B. Self-Adhesive Vinyl Labels: Preprinted, flexible label laminated with a clear, weather- and chemical-resistant coating and matching wraparound adhesive tape for securing ends of legend label. Heat shrink tubing, or sleeve type wire markers are also acceptable.

A. Write-On Tags shall not be allowed.

B. Snap-Around Labels: Slit, pretensioned, flexible, preprinted, color-coded acrylic sleeve, with diameter sized to suit diameter of raceway or cable it identifies and to stay in place by gripping action.

C. Snap-Around, Color-Coding Bands: Slit, pretensioned, flexible, solid-colored acrylic sleeve, 2 inches (50 mm) long, with diameter sized to suit diameter of raceway or cable it identifies and to stay in place by gripping action.

2.4 CONDUCTOR IDENTIFICATION MATERIALS

A. Color-Coding Conductor Tape: Colored, self-adhesive vinyl tape not less than 3 mils thick by 1 to 2 inches wide.

B. Self-Adhesive Vinyl Labels: Preprinted, flexible label laminated with a clear, weather- and chemical-resistant coating and matching wraparound adhesive tape for securing ends of legend label. Heat shrink tubing, or sleeve type wire markers are also acceptable.

C. Marker Tapes: Vinyl or vinyl-cloth, self-adhesive wraparound type, with circuit identification legend machine printed by thermal transfer or equivalent process.

D. Write-On Tags shall not be allowed.

2.5 FLOOR MARKING TAPE

A. 2-inch-wide, 5-mil pressure-sensitive vinyl tape, with black and white stripes and clear vinyl overlay.

2.6 UNDERGROUND-LINE WARNING TAPE

A. Tape:

1. Recommended by manufacturer for the method of installation and suitable to identify and locate underground electrical and communications utility lines.
2. Printing on tape shall be permanent and shall not be damaged by burial operations.
3. Tape material and ink shall be chemically inert, and not subject to degrading when exposed to acids, alkalis, and other destructive substances commonly found in soils.

B. Color and Printing:

1. Comply with ANSI Z535.1 through ANSI Z535.5.
2. Inscriptions for Red-Colored Tapes: ELECTRIC LINE, HIGH VOLTAGE.
3. Inscriptions for Orange-Colored Tapes: TELEPHONE CABLE, CATV CABLE, COMMUNICATIONS CABLE, OPTICAL FIBER CABLE.

C. Tag: Type I:

1. Pigmented polyolefin, bright-colored, compounded for direct-burial service.
2. Thickness: 4 mils.
3. Weight: 18.5 lb/1000 sq. ft.
4. 3-Inch Tensile According to ASTM D 882: 30 lbf, and 2500 psi.

D. Tag: Type ID:

1. Detectable three-layer laminate, consisting of a printed pigmented polyolefin film, a solid aluminum-foil core, and a clear protective film that allows inspection of the continuity of the conductive core, bright-colored, compounded for direct-burial service.
2. Overall Thickness: 5 mils.
3. Foil Core Thickness: 0.35 mil.
4. Weight: 28 lb/1000 sq. ft.
5. 3-Inch Tensile According to ASTM D 882: 70 lbf, and 4600 psi.

2.7 WARNING LABELS AND SIGNS

A. Comply with NFPA 70 and 29 CFR 1910.145.

B. Self-Adhesive Warning Labels: Factory-printed, multicolor, pressure-sensitive adhesive labels, configured for display on front cover, door, or other access to equipment unless otherwise indicated.

C. Baked-Enamel Warning Signs:

1. Preprinted aluminum signs, punched or drilled for fasteners, with colors, legend, and size required for application.
2. 1/4-inch grommets in corners for mounting.
3. Nominal size, 7 by 10 inches.

D. Metal-Backed, Butyrate Warning Signs:

1. Weather-resistant, nonfading, preprinted, cellulose-acetate butyrate signs with 0.0396-inch galvanized-steel backing; and with colors, legend, and size required for application.
2. 1/4-inch grommets in corners for mounting.
3. Nominal size, 10 by 14 inches.

E. Warning label and sign shall include, but are not limited to, the following legends:

1. Multiple Power Source Warning: "DANGER - ELECTRICAL SHOCK HAZARD - EQUIPMENT HAS MULTIPLE POWER SOURCES."
2. Workspace Clearance Warning: "WARNING - OSHA REGULATION - AREA IN FRONT OF ELECTRICAL EQUIPMENT MUST BE KEPT CLEAR FOR 36 INCHES."

2.8 INSTRUCTION SIGNS

A. Engraved, laminated acrylic or melamine plastic, minimum 1/16 inch thick for signs up to 20 sq. inches and 1/8 inch thick for larger sizes.

1. Engraved legend with black letters on white face.
2. Punched or drilled for mechanical fasteners.
3. Framed with mitered acrylic molding and arranged for attachment at applicable equipment.

B. Adhesive Film Label: Machine printed, in black, by thermal transfer or equivalent process. Minimum letter height shall be 3/8 inch.

C. Adhesive Film Label with Clear Protective Overlay: Machine printed, in black, by thermal transfer or equivalent process. Minimum letter height shall be 3/8 inch. Overlay shall provide a weatherproof and UV-resistant seal for label.

2.9 EQUIPMENT IDENTIFICATION LABELS

A. Adhesive Film Label with Clear Protective Overlay: Machine printed, in black, by thermal transfer or equivalent process. Minimum letter height shall be 3/8 inch. Overlay shall provide a weatherproof and UV-resistant seal for label.

B. Self-Adhesive, Engraved, Laminated Acrylic or Melamine Label: Adhesive backed, with white letters on a dark-gray background. Minimum letter height shall be 3/8 inch.

C. Stenciled Legend: In nonfading, waterproof, black ink or paint. Minimum letter height shall be 1 inch.

2.10 MISCELLANEOUS IDENTIFICATION PRODUCTS

A. Paint: Comply with requirements in painting Sections for paint materials and application requirements. Select paint system applicable for surface material and location (exterior or interior).

B. Fasteners for Labels and Signs: Self-tapping, stainless-steel screws or stainless-steel machine screws with nuts and flat and lock washers.

PART 3 - EXECUTION

3.1 CONDUCTOR LABELING SCHEME

A. All control and instrumentation conductors shall be labeled with a “To/From” labeling scheme. Each conductor label shall have two lines of text. The first line of text shall indicate the enclosure and terminal where the wire is to terminate on the other end. The second line of text shall indicate the enclosure and terminal where the wire is to terminate on this end. The following example illustrates the “To/From” labeling scheme:

1. A wire is connected between a VFD and an LCP. The VFD equipment tag is VFD-100 and the LCP equipment tag is LCP-100. The connecting terminal at the VFD enclosure is terminal “5”. The connecting terminal at the LCP is terminal “7”. This wire would have the following labels:
    a. The wire label at the VFD end:
        Top Line: “LCP-100 : 7”
        Bottom Line: “VFD-100 : 5”
    b. The wire label at the LCP end:
        Top Line: “VFD-100 : 5”
        Bottom Line: “LCP-100 : 7”

3.2 INSTALLATION

A. Location: Install identification materials and devices at locations for most convenient viewing without interference with operation and maintenance of equipment.

B. Apply identification devices to surfaces that require finish after completing finish work.

C. Self-Adhesive Identification Products: Clean surfaces before application, using materials and methods recommended by manufacturer of identification device.

D. Attach signs and plastic labels that are not self-adhesive type with mechanical fasteners appropriate to the location and substrate.

E. System Identification Color-Coding Bands for Raceways and Cables: Each color-coding band shall completely encircle cable or conduit. Place adjacent bands of two-color markings in contact, side by side. Locate bands at changes in direction, at penetrations of walls and floors, at 50-foot maximum intervals in straight runs, and at 25-foot maximum intervals in congested areas.

F. Underground-Line Warning Tape: During backfilling of trenches install continuous underground-line warning tape directly above line at 6 to 8 inches below finished grade. Use multiple tapes where width of multiple lines installed in a common trench or concrete envelope exceeds 16 inches overall.

G. Painted Identification: Comply with requirements in painting Sections for surface preparation and paint application.

3.3 IDENTIFICATION SCHEDULE

A. Accessible Raceways and Metal-Clad Cables, 600 V or Less, for Service, Feeder, and Branch Circuits More Than 30A, and 120V to ground: Install labels at 10-foot maximum intervals.

B. Accessible Raceways and Cables within Buildings: Identify the covers of each junction and pull box of the following systems with self-adhesive vinyl labels with the wiring system legend and system voltage. System legends shall be as follows:

1. Emergency Power.
2. Power.
3. UPS.

C. Power-Circuit Conductor Identification, 600 V or Less: For conductors in vaults, pull and junction boxes, manholes, and handholes, use color-coding conductor tape to identify the phase.

1. Color-Coding for Phase Identification, 600 V or Less: Use colors listed below for ungrounded service, feeder and branch-circuit conductors.

    a. Colors for 208/120-V Circuits:

        1) Phase A: Black.
        2) Phase B: Red.

3) Phase C: Blue.

b. Colors for 480/277-V Circuits:

1) Phase A: Brown.
2) Phase B: Orange.
3) Phase C: Yellow.

c. Field-Applied, Color-Coding Conductor Tape: Apply in half-lapped turns for a minimum distance of 6 inches from terminal points and in boxes where splices or taps are made. Apply last two turns of tape with no tension to prevent possible unwinding. Locate bands to avoid obscuring factory cable markings.

D. Install instructional sign including the color-code for grounded and ungrounded conductors using adhesive-film-type labels.

E. Conductors to Be Extended in the Future: Attach marker tape to conductors and list source.

F. Auxiliary Electrical Systems Conductor Identification: Identify field-installed alarm, control, and signal connections.

1. Identify conductors, cables, and terminals in enclosures and at junctions, terminals, and pull points. Identify by system and circuit designation.
2. Use system of marker tape designations that is uniform and consistent with system used by manufacturer for factory-installed connections.
3. Coordinate identification with Project Drawings, manufacturer's wiring diagrams, and the Operation and Maintenance Manual.

G. Locations of Underground Lines: Identify with underground-line warning tape for power, lighting, communication, and control wiring and optical fiber cable.

1. Limit use of underground-line warning tape to direct-buried cables.
2. Install underground-line warning tape for both direct-buried cables and cables in raceway.

H. Workspace Indication: Install floor marking tape to show working clearances in the direction of access to live parts. Workspace shall be as required by NFPA 70 and 29 CFR 1926.403 unless otherwise indicated. Do not install at flush-mounted panelboards and similar equipment in finished spaces.

I. Warning Labels for Indoor Cabinets, Boxes, and Enclosures for Power and Lighting: Self-adhesive warning labels.

1. Comply with 29 CFR 1910.145.
2. Identify system voltage with black letters on an orange background.
3. Apply to exterior of door, cover, or other access.
4. For equipment with multiple power or control sources, apply to door or cover of equipment including, but not limited to, the following:

a. Power transfer switches.
b. Controls with external control power connections.

J. Operating Instruction Signs: Install instruction signs to facilitate proper operation and maintenance of electrical systems and items to which they connect. Install instruction signs with approved legend where instructions are needed for system or equipment operation.

K. Emergency Operating Instruction Signs: Install instruction signs with white legend on a red background with minimum 3/8-inch-high letters for emergency instructions at equipment used for power transfer.

L. Equipment Identification Labels: On each unit of equipment, install unique designation label that is consistent with wiring diagrams, schedules, and the Operation and Maintenance Manual. Apply labels to disconnect switches and protection equipment, central or master units, control panels, control stations, terminal cabinets, and racks of each system. Systems include power, lighting, control, communication, signal, monitoring, and alarm systems unless equipment is provided with its own identification.

1. Labeling Instructions:

   a. Indoor Equipment: Self-adhesive, engraved, laminated acrylic or melamine label. Unless otherwise indicated, provide a single line of text with 1/2-inch-high letters on 1-1/2-inch-high label; where two lines of text are required, use labels 2 inches high.
   b. Outdoor Equipment: Engraved, laminated acrylic or melamine label.
   c. Elevated Components: Increase sizes of labels and letters to those appropriate for viewing from the floor.
   d. Unless provided with self-adhesive means of attachment, fasten labels with appropriate mechanical fasteners that do not change the NEMA or NRTL rating of the enclosure.

END OF SECTION 260553

SECTION 260573 – ELECTRICAL TESTING WITH COORDINATION STUDY

PART 1 – GENERAL

1.1 SCOPE

A. The contractor shall furnish short-circuit and protective device coordination studies as prepared by the electrical equipment manufacturer or an approved engineering firm.

B. The contractor shall furnish an Arc Flash Hazard Analysis Study per the requirements set forth in NFPA 70E. The arc flash hazard analysis shall be performed according to the IEEE 1583 equations that are presented in NFPA 70E-2004, Annex D.

C. The scope of the studies shall include all new distribution equipment supplied by the equipment Manufacturer under this contract as well as all existing distribution equipment at the customer facility.

D. The contractor shall perform electrical tests as described in Part 3 of this document.

1.2 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American National Standards Institute (ANSI):

   a. 450, Recommended Practice for Maintenance, Testing, and Replacement of Large Lead Storage Batteries for Generator Stations and Substations.
   b. C2, National Electric Safety Code.
   c. C37.13, Standard for Low Voltage AC Power Circuit Breakers Used in Enclosures
   d. C37.20.1, Metal-Enclosed Low Voltage Power Circuit Breaker Switchgear.
   e. C37.20.2, Metal-Clad and Station-Type Cubicle Switchgear.
   f. C37.20.3, Metal-Enclosed Interrupter Switchgear.
   g. C57.12.00, Standard General Requirements for Liquid-Immersed Distribution, Power and Regulating Transformers
   h. C62.33, Standard Test Specifications for Varistor Surge Protective Devices.

2. American Society for Testing and Materials (ASTM):

   a. D665, Standard Test Method for Rust Preventing Characteristics of Inhibited Mineral Oil in the Presence of Water.
   b. D877, Standard Test Method for Dielectric Breakdown Voltage of Insulating Liquids Using Disk Electrodes.
   c. D923, Standard Test Method for Sampling Electrical Insulating Liquids.
   d. D924, Standard Test Methods for A-Class Characteristics and Relative Permittivity (Dielectric Constant) of Electrical Insulating Liquids.
   e. D971, Standard Test Method for Interfacial Tension of 0.1 against Water by the Ring Method.

f. D974, Standard Test Method for Acid and Base Number by Color-Indicator Titration.
g. D1298, Standard Test Method for Density, Relative Density (Specific Gravity), or API Gravity of Crude Petroleum and Liquid Petroleum Products by Hydrometer Method.
h. D1500, Standard Test Method for ASTM Color of Petroleum Products.
i. D1524, Standard Test Method for Visual Examination of Used Electrical Insulating Oils of Petroleum Origin in the Field.
j. D1533, Standard Test Methods for Water in Insulating Liquids.
k. D1816, Standard Test Method for Dielectric Breakdown Voltage on Insulating Oils of Petroleum Origin Using VDE Electrodes.
l. D2285, Standard Test Method for Interfacial Tension of Electrical Insulating Oils of Petroleum Origin against Water by the Drop-Weight Method.

3. Institute of Electrical and Electronics Engineers (IEEE):

a. 43, Recommended Practice for Testing Insulating Resistance of Rotating Machinery.
b. 48, Standard Test Procedures and Requirements for High-Voltage Alternating-Current Cable Terminators.
c. 81, Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System.
d. 95, Recommended Practice for Insulation Testing of Large AC Rotating Machinery with High Direct Voltage.
e. 118, Standard Test Code for Resistance Measurement.
f. 141, Recommended Practice for Electric Power Distribution and Coordination of Industrial Power Systems.
g. 242, Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems
h. 399, Recommended Practice for Industrial and Commercial Power System Analysis
i. 400, Guide for Making High-Direct-Voltage Tests on Power Cable Systems in the Field.
j. 1015, Recommended Practice for Apply Low-Voltage Circuit Breakers Used in Industrial and Commercial Power Systems
k. 1584, Guide for Performing Arc-Flash Hazard Calculations

4. National Electrical Manufacturers Association (NEMA):

a. AB 4, Guideline for Inspection and Preventive Maintenance of Molded Case Circuit Breakers Used in Commercial and Industrial Applications.
b. PB 2, Deadfront Distribution Switchboards.
c. WC 7, Cross-Linked-Thermosetting-Polyethylene-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy.
d. WC 8, Ethylene-Propylene-Rubber-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy.

5. International Electrical Testing Association (NETA): ATS, Acceptance Testing Specifications for Electrical Power Distribution Equipment and Systems.

6. National Fire Protection Association (NFPA):

a. 70, National Electrical Code (NEC).
b. 70E, Standard for Electrical Safety Requirements for Employee Workplaces.

1.3 SUBMITTALS

A. Analysis Studies Submittal: Submit prior to receiving final approval of the distribution equipment submittal and prior to release of equipment manufacturing. If formal completion of the studies may cause delay in equipment manufacturing, approval may be obtained from the Engineer may be obtained for preliminary submittal of sufficient study data to ensure that the selection of device and characteristics will be satisfactory.

1. The results of the short-circuit, protective device coordination and arc flash hazard analysis studies shall be summarized in a final report and submitted to the Design Engineer
2. The report shall include the following sections:.
   a. Executive Summary
   b. Descriptions, purpose, basis and scope of the study
   c. Tabulations of circuit breaker, fuse and other protective device ratings versus short circuit duties
   d. Protective device time versus current coordination curves, tabulations of relay and circuit breaker trips unit settings, fuse selection
   e. Fault current calculations including a definition of terms and guide for interpretation of the computer printout\
   f. Details of the incident energy and flash protection boundary calculations
   g. Recommendations for system improvements, where needed
   h. One-line diagram
3. Arc flash labels shall be provided in hard copy only
4. Sample copy of individual device test form.
5. Sample copy of individual system test form.

B. Administrative Submittals: Submit 30 days prior to performing inspections or tests:

1. Schedule for performing inspection and tests.
2. List of references to be used for each test.
3. Sample copy of equipment and materials inspection form(s).
4. Sample copy of individual device test form.
5. Sample copy of individual system test form.

C. Quality Control Submittals: Submit within 14 days after completion of test:

1. Test or inspection reports and certificates for each electrical item tested.

D. Contract Closeout Submittals:

1. Operation and Maintenance Data:
   a. In accordance with references elsewhere in these specifications.
   b. After test of inspection reports and certificates have been reviewed by ENGINEER and returned, insert a copy of each in operation and maintenance manual.

1.4 QUALIFICATIONS

A. The short-circuit, protective device coordination and arc flash hazard analysis studies shall be conducted under the supervision and approval of a Registered Professional Electrical Engineer skilled in performing and interpreting the power system studies.

B. The Engineer shall be a full-time employee of the equipment manufacturer or an approved engineering firm.

C. The Engineer shall have a minimum of five (5) years of experience in performing power system studies.

D. The Engineer shall submit references of at least ten actual short-circuit, protective device coordination and arc flash hazard analysis studies performed over the last five years.

1.5 QUALITY ASSURANCE

A. Test equipment shall have an operating accuracy equal to, or greater than, requirements established by NETA ATS.

B. Test instrument calibration shall be in accordance with NETA ATS.

1.6 SEQUENCING AND SCHEDULING

A. Perform short-circuit, protective device coordination and arc flash hazard analysis studies prior to final approval of distribution equipment submittal

B. Perform inspection and electrical tests after equipment has been installed.

C. Perform tests with apparatus de-energized whenever feasible.

D. Inspection and electrical tests on energized equipment are to be:
   1. Scheduled with OWNER prior to de-energization.
   2. Minimized to avoid extended period of interruption to the operating plant equipment.

E. Notify OWNER at least 24 hours prior to performing tests on energized electrical equipment.

PART 2 – PRODUCTS

2.1 STUDIES

A. Contractor is to furnish short-circuit and protective device coordination studies as prepared by equipment manufacturer or an approved engineering firm.

B. The contractor shall furnish an Arc Flash Hazard Analysis Study per NFPA 70E Article 130.3 and Annex D.

2.2 DATA COLLECTION

A. Contractor shall furnish all data as required by the power system studies. The Engineer performing the short-circuit, protective device coordination and arc flash hazard analysis studies shall furnish the Contractor with a listing of required data immediately after award of the contract. The Contractor shall expedite collection of the data to assure completion of the studies as required for final approval of the distribution equipment shop drawings and/or prior to the release of the equipment for manufacturing.

B. Source combination may include present and future motors and generators

C. Load data utilized may include existing and proposed loads obtained from Contract Documents provided by Owner or Contractor

2.3 SHORT-CIRCUIT AND PROTECTIVE DEVICE EVALUATION STUDY

A. Use actual conductor impedances if known. If unknown, use typical conductor impedances based on IEEE Standard 141-1993.

B. Transformer design impedances shall be used when test impedances are not available.

C. Provide the following:
1. Calculation methods and assumptions
2. One-line diagram of the system being evaluated
3. Source impedance data, including utility system and motor fault contribution characteristics
4. Tabulations of calculated quantities
5. Results, conclusions, and recommendations.

D. Calculate short-circuit momentary and interrupting duties for a three-phase bolted fault at each:
1. Electric utility's supply termination point
2. Incoming switchgear
3. Unit substation primary and secondary terminals
4. Low voltage switchgear
5. Motor control centers
6. Standby generators and automatic transfer switches
7. Branch circuit panelboards
8. Other significant locations throughout the system

E. For grounded systems, provide a bolted line-to-ground fault current study for areas as defined for the three-phase bolted fault short-circuit study.

F. Protective Device Evaluation
1. Evaluate equipment and protective devices and compare to short circuit ratings
2. Adequacy of switchgear, motor control centers, and panelboard bus bars to withstand short-circuit stresses
3. Notify Owner in writing, of existing, circuit protective devices improperly rated for the calculated available fault current.

2.4 PROTECTIVE DEVICE COORDINATION STUDY

A. Proposed protective device coordination time-current curves (TCC) shall be displayed on log-log scale graphs

B. Include on each TCC graph, a complete title and one-line diagram with legend identifying the specific portion of the system covered.

C. Terminate device characteristic curves at a point reflecting maximum symmetrical or asymmetrical fault current to which the device is exposed.

D. Identify the device associated with each curve by manufacturer type, function, and, if applicable, tap, time delay, and instantaneous settings recommended.

E. Plot the following characteristics on the TCC graphs, where applicable:
1. Electric utility's overcurrent protective device
2. Medium voltage equipment overcurrent relays
3. Medium and low voltage fuses including manufacturer's minimum melt, total clearing, tolerance, and damage bands
4. Low voltage equipment circuit breaker trip devices, including manufacturer's tolerance bands
5. Transformer full-load current, magnetizing inrush current, and ANSI through-fault protection curves
6. Conductor damage curves
7. Ground fault protective devices, as applicable
8. Pertinent motor starting characteristics and motor damage points, where applicable
9. Pertinent generator short-circuit decrement curve and generator damage point
10. The largest feeder circuit breaker in each motor control center and applicable panelboard

F. Provide adequate time margins between device characteristics such that selective operation is provided, while providing proper protection.

2.5 ARC FLASH HAZARD ANALYSIS

A. The arc flash hazard analysis shall be performed according to the IEEE 1584 equations that are presented in NFPA70E-2004, Annex D.

B. The flash protection boundary and the incident energy shall be calculated at all significant locations in the electrical distribution system (switchboards, switchgear, motor-control centers, panelboards, busway and splitters) where work could be performed on energized parts.

C. The Arc-Flash Hazard Analysis shall include all significant locations in 240 volt and 208 volt systems fed from transformers equal to or greater than 125 kVA where work could be performed on energized parts.

D. Safe working distances shall be based upon the calculated arc flash boundary considering an incident energy of 1.2 cal/cm2.

E. When appropriate, the short circuit calculations and the clearing times of the phase overcurrent devices will be retrieved from the short-circuit and coordination study model.

Ground overcurrent relays should not be taken into consideration when determining the clearing time when performing incident energy calculations.

F. The short-circuit calculations and the corresponding incident energy calculations for multiple system scenarios must be compared and the greatest incident energy must be uniquely reported for each equipment location. Calculations must be performed to represent the maximum and minimum contributions of fault current magnitude for all normal and emergency operating conditions. The minimum calculation will assume that the utility contribution is at a minimum and will assume a minimum motor contribution (all motors off). Conversely, the maximum calculation will assume a maximum contribution from the utility and will assume the maximum amount of motors to be operating. Calculations shall take into consideration the parallel operation of synchronous generators with the electric utility, where applicable.

G. The incident energy calculations must consider the accumulation of energy over time when performing arc flash calculations on buses with multiple sources. Iterative calculations must take into account the changing current contributions, as the sources are interrupted or decremented with time. Fault contribution from motors and generators should be decremented as follows:

1. Fault contribution from induction motors should not be considered beyond 3-5 cycles.
2. Fault contribution from synchronous motors and generators should be decayed to match the actual decrement of each as closely as possible (e.g. contributions from permanent magnet generators will typically decay from 10 per unit to 3 per unit after 10 cycles).

H. For each equipment location with a separately enclosed main device (where there is adequate separation between the line side terminals of the main protective device and the work location), calculations for incident energy and flash protection boundary shall include both the line and load side of the main breaker.

I. When performing incident energy calculations on the line side of a main breaker (as required per above), the line side and load side contributions must be included in the fault calculation.

J. Mis-coordination should be checked amongst all devices within the branch containing the immediate protective device upstream of the calculation location and the calculation should utilize the fastest device to compute the incident energy for the corresponding location.

K. Arc Flash calculations shall be based on actual overcurrent protective device clearing time. Maximum clearing time will be capped at 2 seconds based on IEEE 1584-2002 section B.1.2. Where it is not physically possible to move outside of the flash protection boundary in less than 2 seconds during an arc flash event, a maximum clearing time based on the specific location shall be utilized.

2.6 REPORT SECTIONS

A. Input data shall include, but not be limited to the following:

1. Feeder input data including feeder type (cable or bus), size, length, number per phase, conduit type (magnetic or non-magnetic) and conductor material (copper or aluminum).
2. Transformer input data, including winding connections, secondary neutral-ground connection, primary and secondary voltage ratings, kVA rating, impedance, % taps and phase shift.
3. Reactor data, including voltage rating, and impedance.
4. Generation contribution data, (synchronous generators and Utility), including short-circuit reactance (X"d), rated MVA, rated voltage, three-phase and single line-ground contribution (for Utility sources) and X/R ratio.
5. Motor contribution data (induction motors and synchronous motors), including shortcircuit reactance, rated horsepower or kVA, rated voltage, and X/R ratio.

B. Short-Circuit Output Data shall include, but not be limited to the following reports:
   1. Low Voltage Fault Report shall include a section for three-phase and unbalanced fault calculations and shall show the following information for each applicable location:
      a. Voltage
      b. Calculated fault current magnitude and angle
      c. Fault point X/R ratio
      d. Equivalent impedance
   2. Momentary Duty Report shall include a section for three-phase and unbalanced fault calculations and shall show the following information for each applicable location:
      a. Voltage
      b. Calculated symmetrical fault current magnitude and angle
      c. Fault point X/R ratio
      d. Calculated asymmetrical fault currents
      e. Equivalent impedance
   3. Interrupting Duty Report shall include a section for three-phase and unbalanced fault calculations and shall show the following information for each applicable location:
      a. Voltage
      b. Calculated symmetrical fault current magnitude and angle
      c. Fault point X/R ratio
      d. No AC Decrement (NACD) Ratio
      e. Equivalent impedance
      f. Multiplying factors for 2, 3, 5 and 8 cycle circuit breakers

C. Recommended Protective Device Settings:
   1. Phase and Ground Relays:
      a. Current transformer ratio
      b. Current setting
      c. Time setting
      d. Instantaneous setting
      e. Recommendations on improved relaying systems, if applicable.
   2. Circuit Breakers:
      a. Adjustable pickups and time delays (long time, short time, ground)
      b. Adjustable time-current characteristic
      c. Adjustable instantaneous pickup
      d. Recommendations on improved trip systems, if applicable.

D. Incident energy and flash protection boundary calculations

1. Arcing fault magnitude
2. Protective device clearing time
3. Duration of arc
4. Arc flash boundary
5. Working distance
6. Incident energy
7. Hazard Risk Category
8. Recommendations for arc flash energy reduction

PART 3 – EXECUTION

3.1 GENERAL

A. Tests specified in this section are to be performed in accordance with the requirements elsewhere in these specifications.

B. Coordination with local Utilities to obtain necessary information to perform the tests specified in this section is the responsibility of the Contractor. All costs incurred in obtaining required information shall be borne by the Contractor.

B. Tests and inspection shall establish that:

1. Electrical equipment is operational within industry and manufacturer's tolerances.
2. All trip units are adjusted to avoid erroneous tripping of circuit breakers.
2. Installation operates properly.
3. Equipment is suitable for energization.
4. Installation conforms to requirements of Contract Documents and NFPA 70, NFPA 70E, and ANSI C2.

C. Perform inspection and testing in accordance with NETA ATS, industry standards, and manufacturer's recommendations.

D. Adjust mechanisms and moving parts for free mechanical movement.

E. Adjust adjustable relays and sensors to correspond to operating conditions, or as recommended by manufacturer.

F. Verify nameplate data for conformance to Contract Documents.

G. Realign equipment not properly aligned and correct un-levelness.

H. Properly anchor electrical equipment found to be inadequately anchored.

I. Tighten accessible bolted connections, including wiring connections, with calibrated torque wrench to manufacturer's recommendations, or as otherwise specified.

J. Clean contaminated surfaces with cleaning solvents as recommended by manufacturer.

K. Provide proper lubrication of applicable moving parts.

L. Inform OWNER of working clearances not in accordance with NFPA 70.

M. Investigate and repair or replace:

1. Electrical items that fail tests.
2. Active components not operating in accordance with manufacturer's instructions.
3. Damaged electrical equipment.

N. Electrical Enclosures:

1. Remove foreign material and moisture from enclosure interior.
2. Vacuum and wipe clean enclosure interior.
3. Remove corrosion found on metal surfaces.
4. Repair or replace, as determined by OWNER, door and panel sections having dented surfaces.
5. Repair or replace, as determined by OWNER, poor fitting doors and panel sections.
6. Repair or replace improperly operating latching, locking, or interlocking devices.
7. Replace missing or damaged hardware.
8. Finish:
   a. Provide matching paint and touch up scratches and mars.
   b. If required due to extensive damage, as determined by OWNER, refinish the entire assembly.

O. Replace fuses and circuit breakers that do not conform to size and type required by the Contract Documents.

3.2 COORDINATION STUDY FIELD ADJUSTMENT

A. Adjust relay and protective device settings according to the recommended settings table provided by the coordination study.

B. Make minor modifications to equipment as required to accomplish conformance with short circuit and protective device coordination studies.

C. Notify Owner in writing of any required major equipment modifications.

3.3 ARC FLASH WARNING LABELS

A. The contractor of the Arc Flash Hazard Analysis shall provide a 3.5 in. x 5 in. thermal transfer type label of high adhesion polyester for each work location analyzed.

B. All labels will be based on recommended overcurrent device settings and will be provided after the results of the analysis have been presented to the owner and after any system changes, upgrades or modifications have been incorporated in the system.

C. The label shall include the following information, at a minimum:
1. Location designation
2. Nominal voltage
3. Flash protection boundary
4. Hazard risk category
5. Incident energy
6. Working distance

D. Labels shall be machine printed, with no field markings.

E. Arc flash labels shall be provided in the following manner and all labels shall be based on recommended overcurrent device settings.
1. For each 600, 480 and applicable 208 volt panelboard, one arc flash label shall be provided.
2. For each motor control center, one arc flash label shall be provided.
3. For each low voltage switchboard, one arc flash label shall be provided.
4. For each switchgear, one flash label shall be provided.
5. For medium voltage switches one arc flash label shall be provided

3.4 LOW VOLTAGE CABLES, 600 VOLTS MAXIMUM

A. Visual and Mechanical Inspection:

1. Inspect Each Individual Exposed Power Cable No. 4 and Larger For:
   a. Physical damage.
   b. Proper connections in accordance with single-line diagram.
   c. Cable bends that do not conform with manufacturer's minimum allowable bending radius where applicable.
   d. Color coding conformance with specifications.
   e. Proper circuit identification.
2. Mechanical Connections For:
   a. Proper lug type for conductor material.
   b. Proper lug installation.
   c. Bolt torque level in accordance with NETA ATS, Table 10.1, unless otherwise specified by manufacturer.
3. Shielded Instrumentation Cables For:
   a. Proper Shield grounding.
   b. Proper terminations.
   c. Proper circuit identification.
4 Control Cables For:
   a. Proper termination.
   b. Proper circuit identification.
5. Cables Terminated Through Window Type CTs: Verify that neutrals and grounds are terminated for correct operation of protective devices.

B. Electrical Tests:

1. Insulation Resistance Tests:
   a. Applied megohm-meter dc voltage in accordance with NETA ATS, Table 10.2.
   b. Phase-to-phase and phase-to-ground for 1 minute on each pole.
   c. Insulation resistance values equal to, or greater than ohm values established by manufacturer.
   d. Provide test reports to Engineer and Owner that show where test measurements were taken and the results
2. Contact Resistance Tests:
   a. Contact resistance in micro-ohms across each switch blade and fuse holder.
   b. Investigate deviation of 50% or more form adjacent poles or similar switches.

3.5 MOLDED CASE CIRCUIT BREAKERS

A. General: Inspection and testing limited to circuit breakers rated 400 amperes and larger.

B. Visual and Mechanical Inspection:

1. Proper mounting.
2. Proper conductor size.
3. Feeder designation according to nameplate and one-line diagram.
4. Cracked casings.
5. Connection bolt torque level in accordance with NETA ATS, Table 10.1.
6. Operate frame size and trip setting with circuit breaker schedules or one-line diagram.
7. Compare frame size and trip setting with circuit breaker schedules or one-line diagram.
8. Verify that terminals are suitable for 75 degrees C rated insulated conductors.

C. Electrical Tests:

1. Insulation Resistance Tests:
   a. Utilize 1,000-volt dc megohm-meter for 480- and 600-volt circuit breakers.
   b. Pole-to-pole and pole-to-ground with breaker contacts opened for 1 minute.
   c. Pole-to-pole and pole-to-ground with breaker contacts closed for 1 minute.
   d. Test values to comply with NETA ATS, Table 10.2.
2. Contact Resistance Tests:
   a. Contact resistance in micro-ohms across each pole.
   b. Investigate deviation of 50% or more from adjacent poles and similar breakers.
3. Trip Coordination Study:
   a. Provide coordination study of all new and existing equipment in the facililty.
   b. Adjust all circuit breaker settings per the coordination study.

3.6 INSTRUMENT TRANSFORMERS

A. Visual and Mechanical Inspection:

1. Visually Check Current, Potential, and Control Transformers for:
   a. Cracked insulation.
   b. Broken leads or defective wiring.
   c. Proper connections
   d. Adequate clearances between primary and secondary circuit wiring.
2. Verify Mechanically that:
   a. Grounding and shorting connections have good contact.
   b. Withdrawal mechanism and grounding operation, when applicable, operate properly.
3. Insulation resistance measurement on instrument transformer shall not be less than that shown in NETA ATS, Table 7.1.1.

3.7 METERING

A. Visual and Mechanical Inspection:

1. Verify meter connections in accordance with appropriate diagrams.
2. Verify meter multipliers.
3. Verify that meter types and scales conform to Contract Documents.
4. Check calibration of meters at cardinal points.
5. Check calibration of electrical transducers.

3.8 GROUNDING SYSTEMS

A. Visual and Mechanical Inspection:

1. Equipment and circuit grounds in motor control centers and panelboards assemblies for proper connection and tightness.
2. Ground bus connections in motor control centers and panelboards assemblies for proper termination and tightness.
3. Effective transformer core and equipment grounding.
4. Accessible connections to grounding electrodes for proper fit and tightness.
5. Accessible exothermic-weld grounding connections to verify that molds were fully filled and proper bonding was obtained.
6. Test ground system using 3 point fall of potential test equipment. Ground system must provide less than 5 ohms to ground resistance. Provide test reports to Engineer and Owner that show where test measurements were taken and the results. System must be tested at all ground rods, concrete encased electrodes, ground busses and service entrance locations.

3.9 AC INDUCTION MOTORS

A. General: Inspection and testing limited to motors rated 10 hp and larger.

B. Visual and Mechanical Inspection:

1. Proper electrical and grounding connections.
2. Shaft alignment.
3. Blockage of ventilating air passageways.
4. Operate Motor and Check for:
   a. Excessive mechanical and electrical noise.
   b. Overheating.
   c. Correct rotation.
   d. Check vibration detectors, resistance temperature detectors, or motor inherent protectors for proper operation.
   e. Excessive vibration.
5. Check operation of space heaters.

C. Electrical Tests:

1. Insulation Resistance Tests:
   a. In accordance with IEEE 43 at test voltages established by NETA ATS, Table 10.2 for:
      1) Motors above 200 hp for 10-minute duration with resistances tabulated at 30 seconds, 1 minute, and 10 minutes.

        2) Motors 200 hp and less for 1-minute duration with resistances tabulated at 30 and 60 seconds.
    b. Insulation resistance values equal to, or greater than, ohm values established by manufacturers.
2. Calculate polarization index ratios for motors above 200 hp. Investigate index ratios less than 1.5 for Class A insulation and 2.0 for Class B insulation.
3. Insulation resistance test on insulated bearings in accordance with manufacturer's instructions.
4. Measure running current and voltage, and evaluate relative to load conditions and nameplate full-load amperes.
5. Provide test reports to Engineer and Owner that show where test measurements were taken and the results

3.10 LOW VOLTAGE MOTOR CONTROL

A. Visual and Mechanical Inspection:

1. Proper barrier and shutter installation and operation.
2. Proper operation of indicating and monitoring devices.
3. Proper overload protection for each motor.
4. Improper blockage of air cooling passages.
5. Proper operation of draw out elements.
6. Integrity and contamination of us insulation system.
7. Check Door and Device Interlocking System By:
    a. Closure attempt of device when door is in OFF or OPEN position.
    b. Opening attempt of door when device is in ON or CLOSED position.
8. Check Nameplates for Proper Identification Of:
    a. Equipment title and tag number with latest one-line diagram.
    b. Pushbuttons.
    c. Control switches.
    d. Pilot lights.
    e. Control relays.
    f. Circuit breakers.
    g. Indicating meters.
9. Verify that fuse and circuit breaker sizes and types conform to Contract Documents.
10. Verify that current and potential transformer ratios conform to Contract Documents.
11. Check Bus Connections for High Resistance by Low Resistance Ohmmeter and Calibrated Torque Wrench Applied to Bolted Joints:
    a. Ohm value to be zero.
    b. Bolt torque level in accordance with NETA ATS, Table 10.1, unless otherwise specified by manufacturer.
12. Check Operation and Sequencing of Electrical and Mechanical Interlock Systems by:
    a. Closure attempt for locked open devices.
    b. Opening attempt for locked closed devices.
13. Verify performance of each control device and feature furnished as part of the motor control center.
14. Control Wiring:
    a. Compare wiring to local and remote control, and protective devices with elementary diagrams.
    b. Check for proper conductor lacing and bundling.
    c. Check for proper conductor identification.

d. Check for proper conductor lugs and connections.

15. Exercise active components.
16. Inspect Contactors For:
    a. Correct mechanical operations.
    b. Correct contact gap, wipe, alignment, and pressure.
    c. Correct torque of all connections.
17. Compare overload heater rating with full-load current for proper size.
18. Compare fuse, motor protector, and circuit breaker with motor characteristics for proper size.
19. Perform phasing check on double-ended motor control centers to ensure proper bus phasing from each source.

B. Electrical Tests:

1. Insulation Resistance Tests:
    a. Applied megohm-meter dc voltage in accordance with NETA ATS, Table 10.2.
    b. Bus section phase-to-phase and phase-to-ground for 1 minute on each phase.
    c. Contactor phase-to-ground and across open contacts for 1 minute on each phase.
    d. Starter section phase-to-phase and phase-to-ground on each phase with starter contacts closed and protective devices open.
    e. Test values to comply with NETA ATS, Table 10.2.
2. Current Injection through Overload Unit at 300% of Motor Full-Load Current and Monitor Trip Time:
    a. Trip time in accordance with manufacturer's published data.
    b. Investigate values in excess of 120 seconds.
3. Control Wiring Tests:
    a. Apply secondary voltage to control power and potential circuits.
    b. Check voltage levels at each point on terminal boards and each device terminal.
    c. Insulation resistance test at 1,000 volts dc on control wiring except that connected to solid state components.
        1) Insulation resistance to be 1 megohm minimum.
4. Operational test by initiating control devices to affect proper operation.
5. Provide test reports to Engineer and Owner that show where test measurements were taken and the results

END OF SECTION 260753

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SECTION 262413 - SWITCHBOARDS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Service and distribution switchboards rated 600 V and less.
2. Transient voltage suppression devices.
3. Disconnecting and overcurrent protective devices.
4. Instrumentation.
5. Control power.
6. Accessory components and features.
7. Identification.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product indicated.

B. Shop Drawings: For each switchboard and related equipment.

1. Include dimensioned plans, elevations, sections, and details, including required clearances and service space around equipment. Show tabulations of installed devices, equipment features, and ratings.
2. Include time-current coordination curves for each type and rating of overcurrent protective device included in switchboards.
3. Include schematic and wiring diagrams for power, signal, and control wiring.

1.3 INFORMATIONAL SUBMITTALS

A. Seismic Qualification Certificates: Submit certification that switchboards, overcurrent protective devices, accessories, and components will withstand seismic forces defined in Section 260548 "Vibration and Seismic Controls for Electrical Systems."

B. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.5 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Comply with NEMA PB 2.

C. Comply with NFPA 70.

D. Comply with UL 891.

1.6 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace transient voltage suppression devices that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURED UNITS

A. Manufacturers: Subject to compliance with requirements, the following manufacturer's are approved:

1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
2. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
3. Square D; a brand of Schneider Electric.

B. Front-Connected, Front-Accessible Switchboards:

1. Main Devices: Panel mounted.
2. Branch Devices: Panel mounted.
3. Sections front and rear aligned.

C. Nominal System Voltage: 480Y/277 V

D. Main-Bus Continuous: 400 A.

E. Seismic Requirements: Fabricate and test switchboards according to IEEE 344 to withstand seismic forces defined in Section 260548 "Vibration and Seismic Controls for Electrical Systems."

F. Enclosure: Steel, NEMA 250, Type 1.

1. Enclosure Finish: Factory-applied finish in manufacturer's standard gray finish over a rust-inhibiting primer on treated metal surface.
2. Enclosure: Flat roof; bolt-on rear covers for each section, with provisions for padlocking.

G. Cubical Space Heaters: Factory-installed electric space heaters of sufficient wattage in each vertical section to maintain enclosure temperature above expected dew point.

H. Space-Heater Control: Thermostats to maintain temperature of each section.

I. Space-Heater Power Source: 120-V external branch circuit.

J. Utility Metering Compartment: Fabricated, barrier compartment and section complying with utility company's requirements. If separate vertical section is required for utility metering, match and align with basic switchboard. Provide service entrance label and necessary applicable service entrance features.

K. Bus Transition and Incoming Pull Sections: Matched and aligned with basic switchboard.

L. Hinged Front Panels: Allow access to circuit breaker, metering, accessory, and blank compartments.

M. Pull Box on Top of Switchboard:

1. Adequate ventilation to maintain temperature in pull box within same limits as switchboard.
2. Removable covers shall form top, front, and sides. Top covers at rear shall be easily removable for drilling and cutting.
3. Bottom shall be insulating, fire-resistive material with separate holes for cable drops into switchboard.
4. Cable supports shall be arranged to facilitate cabling and adequate to support cables indicated, including those for future installation.

N. Phase and Neutral Buses and Connections: Three phase, four wire unless otherwise indicated. Tin-plated, high-strength, electrical-grade aluminum alloy with tin-plated aluminum circuit-breaker line connections.

1. Ground Bus: 1/4-by-2-inch minimum size, hard-drawn copper of 98 percent conductivity, equipped with pressure connectors for feeder and branch-circuit ground conductors.
2. Main Phase Buses and Equipment Ground Buses: Uniform capacity for entire length of switchboard's main and distribution sections. Provide for future extensions from both ends.
3. Neutral Buses: 100 percent of the ampacity of phase buses unless otherwise indicated, equipped with pressure connectors for outgoing circuit neutral cables.

O. Future Devices: Equip compartments with mounting brackets, supports, bus connections, and appurtenances at full rating of circuit-breaker compartment.

2.2 TRANSIENT VOLTAGE SUPPRESSION DEVICES

A. Surge Protection Device Description: IEEE C62.41-compliant, integrally mounted, solid-state, parallel-connected, with sine-wave tracking suppression and filtering modules, UL 1449, second edition, short-circuit current rating matching or exceeding the switchboard short-circuit rating, and with the following features and accessories:

1. Fuses, rated at 200-kA interrupting capacity.
2. LED indicator lights for power and protection status.
3. Audible alarm, with silencing switch, to indicate when protection has failed.

4. Form-C contacts rated at 5 A and 250-V ac, one normally open and one normally closed, for remote monitoring of system operation. Contacts shall reverse position on failure of any surge diversion module or on opening of any current-limiting device.
5. Transient-event counter set to totalize transient surges.

B. Peak Single-Impulse Surge Current Rating: 160 kA per mode/320 kA per phase.

C. Withstand Capabilities: 5000 IEEE C62.41, Category C3 (10 kA), 8-by-20-mic.sec. surges with less than 5 percent change in clamping voltage.

D. Protection modes and UL 1449 SVR for grounded wye circuits with 480Y/277 V, three-phase, four-wire circuits shall be as follows:

1. Line to Neutral: 800 V for 480Y/277.
2. Line to Ground: 800 V for 480Y/277.
3. Neutral to Ground: 800 V for 480Y/277.

2.3 DISCONNECTING AND OVERCURRENT PROTECTIVE DEVICES

A. Molded-Case Circuit Breaker (MCCB): Comply with UL 489, with series-connected rating to meet available fault currents.

1. Thermal-Magnetic Circuit Breakers: Inverse time-current element for low-level overloads, and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
2. Adjustable Instantaneous-Trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip setting.
3. Electronic trip circuit breakers with rms sensing; field-replaceable rating plug or field-replicable electronic trip; and the following field-adjustable settings:

   a. Instantaneous trip.
   b. Long- and short-time pickup levels.
   c. Long- and short-time time adjustments.
   d. Ground-fault pickup level, time delay, and I^2t response.

4. Current-Limiting Circuit Breakers: Frame sizes 400 A and smaller; let-through ratings less than NEMA FU 1, RK-5.
5. Molded-Case Circuit-Breaker (MCCB) Features and Accessories:

   a. Standard frame sizes, trip ratings, and number of poles.
   b. Lugs: Mechanical style, suitable for number, size, trip ratings, and conductor material.
   c. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HID for feeding fluorescent and high-intensity discharge (HID) lighting circuits.
   d. Ground-Fault Protection: Integrally mounted relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.
   e. Zone-Selective Interlocking: Integral with electronic trip unit; for interlocking ground-fault protection function.

f. Communication Capability: Din-rail-mounted communication module with functions and features compatible with power monitoring utilizing Modbus TCP.
g. Shunt Trip: 120-V trip coil energized from separate circuit, set to trip at 75 percent of rated voltage.
h. Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage without intentional time delay.
i. Auxiliary Contacts: Two SPDT switches with "a" and "b" contacts; "a" contacts mimic circuit-breaker contacts, "b" contacts operate in reverse of circuit-breaker contacts.
j. Key Interlock Kit: Externally mounted to prohibit circuit-breaker operation; key shall be removable only when circuit breaker is in off position.

B. Insulated-Case Circuit Breaker (ICCB): 100 percent rated, sealed, insulated-case power circuit breaker with interrupting capacity rating to meet available fault current.

1. Fixed circuit-breaker mounting.
2. Two-step, stored-energy closing.
3. Standard-function, microprocessor-based trip units with interchangeable rating plug, trip indicators, and the following field-adjustable settings:

   a. Instantaneous trip.
   b. Long- and short-time time adjustments.
   c. Ground-fault pickup level, time delay, and I^2t response.

4. Zone-Selective Interlocking: Integral with electronic trip unit; for interlocking ground-fault protection function.
5. Remote trip indication and control.
6. Communication Capability: Integral communication module with Modbus TCP or Ethernet IP.
7. Key Interlock Kit: Externally mounted to prohibit circuit-breaker operation; key shall be removable only when circuit breaker is in off position.
8. Control Voltage: 120-V ac.

C. Bolted-Pressure Contact Switch: Operating mechanism uses rotary-mechanical-bolting action to produce and maintain high clamping pressure on the switch blade after it engages the stationary contacts.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Boltswitch, Inc.
   b. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
   c. Pringle Electrical Manufacturing Company, Inc.
   d. Square D; a brand of Schneider Electric.

2. Operating Mechanism: Manual handle operation to close switch; stores energy in mechanism for opening and closing.

   a. Electrical Trip: Operation of lever or push-button trip switch, or trip signal from ground-fault relay or remote-control device, causes switch to open.

b. Mechanical Trip: Operation of mechanical lever, push button, or other device causes switch to open.

3. Auxiliary Switches: Factory installed, single pole, double throw, with leads connected to terminal block, and including one set more than quantity required for functional performance indicated.
4. Service-Rated Switches: Labeled for use as service equipment.
5. Ground-Fault Relay: Comply with UL 1053; self-powered type with mechanical ground-fault indicator, test function, tripping relay with internal memory, and three-phase current transformer/sensor.

    a. Configuration: Integrally mounted relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.

6. Open-Fuse Trip Device: Arranged to trip switch open if a phase fuse opens.

D. High-Pressure, Butt-Type Contact Switch: Operating mechanism uses butt-type contacts and a spring-charged mechanism to produce and maintain high-pressure contact when switch is closed.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. General Electric Company; GE Consumer & Industrial - Electrical Distribution.

2. Operating Mechanism: Manual handle operation to close switch; stores energy in mechanism for opening and closing.

    a. Electrical Trip: Operation of lever or push-button trip switch, or trip signal from ground-fault relay or remote-control device, causes switch to open.
    b. Mechanical Trip: Operation of mechanical lever, push button, or other device causes switch to open.

3. Auxiliary Switches: Factory installed, single pole, double throw, with leads connected to terminal block, and including one set more than quantity required for functional performance indicated.
4. Service-Rated Switches: Labeled for use as service equipment.
5. Ground-Fault Relay: Comply with UL 1053; self-powered type with mechanical ground-fault indicator, test function, tripping relay with internal memory, and three-phase current transformer/sensor.

    a. Configuration: Integrally mounted relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.

6. Open-Fuse Trip Device: Arranged to trip switch open if a phase fuse opens.

E. Fused Switch: NEMA KS 1, Type HD; clips to accommodate specified fuses; lockable handle.

F. Fuses are specified in Section 262813 "Fuses."

2.4 INSTRUMENTATION

A. Instrument Transformers: IEEE C57.13, NEMA EI 21.1, and the following:

1. Current Transformers: IEEE C57.13; 5 A, 60 Hz, secondary and secondary shorting device. Burden and accuracy shall be consistent with connected metering and relay devices.
2. Control-Power Transformers: Dry type, mounted in separate compartments for units larger than 3 kVA.
3. Current Transformers for Neutral and Ground-Fault Current Sensing: Connect secondary wiring to ground overcurrent relays, via shorting terminals, to provide selective tripping of main and tie circuit breaker. Coordinate with feeder circuit-breaker, ground-fault protection.

B. Multifunction Digital-Metering Monitor: Microprocessor-based unit suitable for three- or four-wire systems and with the following features:

1. Switch-selectable digital display of the following values with maximum accuracy tolerances as indicated:

   a. Phase Currents, Each Phase: Plus or minus 1 percent.
   b. Phase-to-Phase Voltages, Three Phase: Plus or minus 1 percent.
   c. Phase-to-Neutral Voltages, Three Phase: Plus or minus 1 percent.
   d. Megawatts: Plus or minus 2 percent.
   e. Megavars: Plus or minus 2 percent.
   f. Power Factor: Plus or minus 2 percent.
   g. Frequency: Plus or minus 0.5 percent.
   h. Accumulated Energy, Megawatt Hours: Plus or minus 2 percent; accumulated values unaffected by power outages up to 72 hours.
   i. Megawatt Demand: Plus or minus 2 percent; demand interval programmable from five to 60 minutes.

2. Mounting: Display and control unit flush or semiflush mounted in instrument compartment door.

2.5 CONTROL POWER

A. Control Circuits: 120-V ac, supplied through secondary disconnecting devices from control-power transformer.

B. Electrically Interlocked Main and Tie Circuit Breakers: Two control-power transformers in separate compartments, with interlocking relays, connected to the primary side of each control-power transformer at the line side of the associated main circuit breaker. 120-V secondaries connected through automatic transfer relays to ensure a fail-safe automatic transfer scheme.

C. Control-Power Fuses: Primary and secondary fuses for current-limiting and overload protection of transformer and fuses for protection of control circuits.

D. Control Wiring: Factory installed, with bundling, lacing, and protection included. Provide flexible conductors for No. 8 AWG and smaller, for conductors across hinges, and for conductors for interconnections between shipping units.

2.6 ACCESSORY COMPONENTS AND FEATURES

A. Portable Test Set: For testing functions of solid-state trip devices without removing from switchboard. Include relay and meter test plugs suitable for testing switchboard meters and switchboard class relays.

B. Spare-Fuse Cabinet: Suitably identified, wall-mounted, lockable, compartmented steel box or cabinet. Arrange for wall mounting.

2.7 IDENTIFICATION

A. Service Equipment Label: NRTL labeled for use as service equipment for switchboards with one or more service disconnecting and overcurrent protective devices.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Receive, inspect, handle, store and install switchboards and accessories according to NEMA PB 2.1.

B. Equipment Mounting: Install switchboards on concrete base, 4-inch nominal thickness. Comply with requirements for concrete base specified in Section 033000 "Cast-in-Place Concrete."

1. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around the full perimeter of concrete base.
2. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
3. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
4. Install anchor bolts to elevations required for proper attachment to switchboards.

C. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from switchboard units and components.

D. Comply with mounting and anchoring requirements specified in Section 260548 "Vibration and Seismic Controls for Electrical Systems."

E. Install filler plates in unused spaces of panel-mounted sections.

F. Install overcurrent protective devices, transient voltage suppression devices, and instrumentation.

1. Set field-adjustable switches and circuit-breaker trip ranges.

G. Install spare-fuse cabinet.

H. Comply with NECA 1.

I. Comply with requirements for terminating feeder bus specified in Section 262500 "Enclosed Bus Assemblies." Drawings indicate general arrangement of bus, fittings, and specialties.

J. Comply with requirements for terminating cable trays specified in Section 260536 "Cable Trays for Electrical Systems." Drawings indicate general arrangement of cable trays, fittings, and specialties.

3.2 IDENTIFICATION

A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs complying with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

B. Switchboard Nameplates: Label each switchboard compartment with a nameplate complying with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

C. Device Nameplates: Label each disconnecting and overcurrent protective device and each meter and control device mounted in compartment doors with a nameplate complying with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

3.3 FIELD QUALITY CONTROL

A. Acceptance Testing Preparation:

1. Test insulation resistance for each switchboard bus, component, connecting supply, feeder, and control circuit.
2. Test continuity of each circuit.

B. Tests and Inspections:

1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
3. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.

C. Switchboard will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports, including a certified report that identifies switchboards included and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

END OF SECTION 262413

SECTION 262416 - PANELBOARDS

PART 1 - GENERAL

1.1 SCOPE OF WORK

A. This section covers electrical panelboards.

1.2 SUBMITTALS

A. Products shall be submitted in accordance with Section 260000, and the Contract Documents, prior to installation.

B. Panel layout with alphanumeric designation, branch circuit breaker sizes and types, AIC rating, bus sizes, bus material and other characteristics.

1.3 QUALITY ASSURANCE

A. NEMA PB-1, Panelboards

B. NEC

C. UL67, Panelboards

PART 2 - PRODUCTS

2.1 PANELBOARDS

A. Dead-front panelboards, including lighting distribution and control panels, shall be furnished and installed as indicated on the Plans. Buses shall be copper. If shown on the drawings as 4 wire, neutral shall be 100% rated. Mounting and type of enclosures shall be as indicated on the Plans. Where not indicated, indoor enclosures shall be NEMA 12 and outdoor enclosures shall be NEMA 4. The minimum interrupting capacity of any device shall be 22 KAIC unless otherwise indicated on the Plans.

B. Protective devices shall be replaceable without disturbing adjacent units, and shall be of the bolt-on type. Snap in protective devices will not be accepted. Wire connectors shall be suitable for wire sizes indicated. Branch circuits shall be numbered as indicated on the Plans, and a complete typed circuit schedule shall be furnished under a transparent cover, and affixed to the inside of the panel access door. Phase busing shall be full height without reduction. Full size neutral and ground bars shall be included, and shall have suitable lugs for each outgoing circuit requiring connection. Spaces for future protective devices provided in lighting panels shall be bused for the maximum device that can be fitted into them.

C. Panelboards shall be finished with a primer, rust resistant phosphate undercoat and two coats of oven baked enamel with finish ANSI grey. They shall be sized to provide a minimum of 4 inches of gutter space on all sides. Doors shall not uncover any live parts, and shall be hinged and have latches that require no tool to operate. Panelboard doors shall be lockable. Lock and two keys shall be furnished.

D. Each panelboard shall have, on the outside of the door, a lamicoid nameplate with 3/4 inch letters as specified elsewhere in these Contract Documents.

E. Panelboards shall be as manufactured by Square D, General Electric, Eaton / Cutler Hammer, or equal.

F. Panelboards shall be service entrance rated where required, and as shown on the Plans.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Panelboards shall be installed as indicated on the plans and according to manufacturer's instructions.

B. Provide grounding per NEC, and Section 260526.

C. Contractor shall verify all NEC clearance requirements prior to installation.

END OF SECTION 262416

SECTION 262726 - WIRING DEVICES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Receptacles, receptacles with integral GFCI, and associated device plates.
2. Weather-resistant receptacles.
3. Snap switches and wall-box dimmers.
4. Solid-state fan speed controls.
5. Wall-switch and exterior occupancy sensors.
6. Communications outlets.

1.2 ADMINISTRATIVE REQUIREMENTS

A. Coordination:

1. Receptacles for Owner-Furnished Equipment: Match plug configurations.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: List of legends and description of materials and process used for premarking wall plates.

1.4 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers' Names: Shortened versions (shown in parentheses) of the following manufacturers' names are used in other Part 2 articles:

1. Appleton Electric Co. (Appleton).

2. Cooper Wiring Devices; Division of Cooper Industries, Inc. (Cooper).
3. Cooper Crouse-Hinds (Crouse-Hinds).
4. Hubbell Incorporated; Wiring Device-Kellems (Hubbell).
5. Killark.
6. Leviton Mfg. Company Inc. (Leviton).
7. Pass & Seymour/Legrand (Pass & Seymour).

B. Source Limitations: Obtain each type of wiring device and associated wall plate from single source from single manufacturer.

2.2 GENERAL WIRING-DEVICE REQUIREMENTS

A. Wiring Devices, Components, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Comply with NFPA 70.

C. Devices that are manufactured for use with modular plug-in connectors may be substituted under the following conditions:

1. Connectors shall comply with UL 2459 and shall be made with stranding building wire.
2. Devices shall comply with the requirements in this Section.

2.3 STRAIGHT-BLADE RECEPTACLES FOR UNCLASSIFIED AREAS

A. General Description

1. Convenience Receptacles, 125 V, 20 A
2. Comply with NEMA WD 1, NEMA WD 6 Configuration 5-20R, UL 498, and FS W-C-596.
3. Straight blade, grounding type, specification grade.
4. Color: White unless Owner or Engineer specifies otherwise. Ivory for weather resistant receptacles. Yellow for corrosion resistant receptacles.
5. Provide weather resistant receptacles for damp and wet areas (including all process areas or areas that may be sprayed down).
6. Provide corrosion resistant receptacles for corrosive areas.

B. Products: Subject to compliance with requirements, provide the following:

1. Dry, non-corrosive locations:
   a. Hubbell; HBL5361 (single), HBL5362 (duplex).
   b. Or Approved Equal.
2. Damp or wet locations:
   a. Hubbell; HBL5361WR (single), HBL5362WR (duplex).
   b. Or Approved Equal.
3. Corrosive locations:
   a. Hubbell; HBL53CM61 (single), HBL53CM62 (duplex).
   b. Or Approved Equal.

2.4 RECEPTACLES FOR CLASSIFIED AREAS

A. General Description

1. Explosion proof, UL Listed for Class 1 Division I and II Groups C & D
2. Rated for 125 V, 20 A
3. Corrosion Resistant with malleable iron mounting box.
4. “Dead-front” construction requiring plug to be inserted and rotated to activate receptacle.
5. Factory Sealed so that seal-offs are not required at the receptacle.
6. If receptacles are to have GFCI, this shall be achieved at the branch circuit overcurrent protective device (typically a lighting panel) in an unclassified space.

B. Products: Subject to compliance with requirements, provide the following:

1. Appleton U-Line Contender series.
2. Crouse-Hinds Arktite Series.
3. Or Approved Equal.

2.5 GFCI RECEPTACLES FOR UNCLASSIFIED AREAS

A. General Description:

1. Duplex GFCI Convenience Receptacles, 125 V, 20 A.
2. Straight blade, feed-through type.
3. Comply with NEMA WD 1, NEMA WD 6, UL 498, UL 943 Class A, and FS W-C-596.
4. Include indicator light that shows when the GFCI has malfunctioned and no longer provides proper GFCI protection.
5. Receptacles shall be tamper and weather resistant.

B. Products: Subject to compliance with requirements, provide the following:

1. Hubbell; GFR5362TR.
2. Or Approved Equal.

2.6 TOGGLE SWITCHES FOR UNCLASSIFIED AREAS

A. General Description:

1. Toggle Switches, 120/277 V, 20A
2. Comply with NEMA WD 1, UL 20, and FS W-S-896.
3. Toggle type, quiet action, specification grade with grounding terminal.
4. Back and side wired, silver alloy contacts.
5. Color: White unless Owner or Engineer specifies otherwise.
6. For corrosive or wet areas, provide a NEMA 4X watertight, dust-tight and corrosion resistant cover.

B. Switches:

1. Products: Subject to compliance with requirements, provide the following:

a. Switches, 120/277 V, 20 A:
   1) Hubbell; HBL1221 (Single Pole); HBL1222 (Double Pole); HBL1223 (Three Way); HBL1224 (Four Way).
   2) Or Approved Equal.

b. Illuminated Switches (illuminated when switch is "off":
   1) Hubbell; HBL1221IL (Single Pole); HBL1223IL (Three Way).
   2) Or Approved Equal.

c. Key-Operated Switches (with factory supplied key):
   1) Hubbell; HBL1221L
   2) Or Approved Equal.

2.7 TOGGLE SWITCHES FOR CLASSIFIED AREAS

A. General Description:

1. Explosion proof, UL Listed for Class 1 Division I and II Groups C & D
2. Rated for 125 V, 20 A
3. Corrosion Resistant with malleable iron body and cover.
4. Factory Sealed so that seal-offs are not required at the receptacle.
5. Front operated handle with stainless steel shaft.
6. With grounding screw.

B. Products: Subject to compliance with requirements, provide the following:

1. Appleton Contender series.
2. Crouse-Hinds EDS Series.
3. Or Approved Equal.

2.8 WALL-BOX DIMMERS

A. Dimmer Switches: Modular, full-wave, solid-state units with integral, quiet on-off switches, with audible frequency and EMI/RFI suppression filters.

B. Control: Continuously adjustable slider; with single-pole or three-way switching. Comply with UL 1472.

C. Incandescent Lamp Dimmers: 120 V; control shall follow square-law dimming curve. On-off switch positions shall bypass dimmer module.

1. 600 W; dimmers shall require no derating when ganged with other devices. Illuminated when "off." Load shall not exceed 80% of dimmer rating.

D. Fluorescent Lamp Dimmer Switches: Modular; compatible with dimmer ballasts; trim potentiometer to adjust low-end dimming; dimmer-ballast combination capable of consistent dimming with low end not greater than 20 percent of full brightness.

2.9 WALL PLATES

A. Single and combination types shall match corresponding wiring devices.

1. Plate-Securing Screws: Metal with head color to match plate finish except for stainless steel wall plates whose screws shall be stainless steel.
2. Material for Finished Office Spaces: Smooth, high-impact thermoplastic, color to match device color.
3. Material for Finished Spaces: Type 304 stainless steel.
4. Material for Unfinished Spaces: Type 304 stainless steel.
5. Material for Damp and corrosive Locations: Cast aluminum with spring-loaded lift cover, and listed and labeled for use in wet and damp locations.

B. Wet-Location, Weatherproof Cover Plates: NEMA 250, complying with Type 3R, weather-resistant**,** die-cast aluminum with lockable cover.

C. Weatherproof, While-In-Use Covers: Where receptacles are required to be weatherproof and physically protected while in use or idle or where shown on the drawings, weatherproof, while-in-use covers shall be used in lieu of other covers. The cover shall have the following features:

1. General Description:

   a. Suitable style receptacle plate with a hinged cover.
   b. Cord port(s) capable of allowing an appropriate size electrical cord(s) to pass through when the cover is closed.
   c. Latching mechanism to allow the enclosure to maintain weatherproof integrity. The latch shall be a tamper resistant (locking/security) style in areas where security is needed.
   d. Sufficiently deep to allow full closure with plug(s) in use.
   e. UL listed per UL Standard 514C and conform to NEC Article 410.57 paragraphs a and b, Article 110.3 and Article 110.11.
   f. Body materials shall be of a flame resistant, self-extinguishing, UV inhibiting, impact resistant, polycarbonate resin. Materials must meet UL Standard 94 HF1.
   g. Mounting screws shall be stainless steel and of sufficient length to properly secure the device and ensure seal to mounting surface.

2. Products: Subject to compliance with requirements, provide the following:

   a. Cooper; TP74 Series.
   b. Or Approved Equal.

2.10 FINISHES

A. Device Color:

1. Wiring Devices Connected to Normal Power System: White unless Owner or Engineer specifies otherwise or otherwise indicated or required by NFPA 70 or device listing.
2. Wiring Devices Connected to UPS or Emergency Power System: Red.
3. TVSS Devices: Blue.

B. Wall Plate Color: For plastic covers, match device color.

2.11 COMMUNICATIONS OUTLETS

A. Jacks shall be TIA/EIA Category 6 Compliant and shall support wiring and be labeled for both T568A and T568B standards. Plates shall be constructed of high-impact, flame-retardant, UL 94V-0 thermoplastic. Plates shall be available in single gang with 1-4 ports and double gang with 8 ports. Color of jacks and plates shall be determined by the Owner.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Comply with NECA 1, including mounting heights listed in that standard, unless otherwise indicated.

B. Coordination with Other Trades:

1. Protect installed devices and their boxes. Do not place wall finish materials over device boxes and do not cut holes for boxes with routers that are guided by riding against outside of boxes.
2. Keep outlet boxes free of plaster, drywall joint compound, mortar, cement, concrete, dust, paint, and other material that may contaminate the raceway system, conductors, and cables.
3. Install device boxes in brick or block walls so that the cover plate does not cross a joint unless the joint is troweled flush with the face of the wall.
4. Install wiring devices after all wall preparation, including painting, is complete.

C. Conductors:

1. Do not strip insulation from conductors until right before they are spliced or terminated on devices.
2. Strip insulation evenly around the conductor using tools designed for the purpose. Avoid scoring or nicking of solid wire or cutting strands from stranded wire.
3. The length of free conductors at outlets for devices shall meet provisions of NFPA 70, Article 300, without pigtails.
4. Existing Conductors:
    a. Cut back and pigtail, or replace all damaged conductors.
    b. Straighten conductors that remain and remove corrosion and foreign matter.
    c. Pigtailing existing conductors is permitted, provided the outlet box is large enough.

D. Device Installation:

1. Wherever possible, wiring devices shall be recess mounted with switches, receptacles and wall plates flush with the wall or surface.
2. Replace devices that have been in temporary use during construction and that were installed before building finishing operations were complete.

3. Keep each wiring device in its package or otherwise protected until it is time to connect conductors.
4. Do not remove surface protection, such as plastic film and smudge covers, until the last possible moment.
5. Connect devices to branch circuits using pigtails that are not less than 6 inches in length.
6. When there is a choice, use side wiring with binding-head screw terminals. Wrap solid conductor tightly clockwise, two-thirds to three-fourths of the way around terminal screw.
7. Use a torque screwdriver when a torque is recommended or required by manufacturer.
8. When conductors larger than No. 12 AWG are installed on 15- or 20-A circuits, splice No. 12 AWG pigtails for device connections.
9. Tighten unused terminal screws on the device.
10. When mounting into metal boxes, remove the fiber or plastic washers used to hold device-mounting screws in yokes, allowing metal-to-metal contact.

E. Receptacle Orientation:

1. Install ground pin of vertically mounted receptacles down, and on horizontally mounted receptacles to the left.
2. Where more than one receptacle is installed in a room, they shall be symmetrically arranged.
3. Set switches and receptacles plumb and vertical to the floor.
4. Set recess-mounted switches and receptacles flush with face of walls.

F. Device Plates: Do not use oversized or extra-deep plates. Repair wall finishes and remount outlet boxes when standard device plates do not fit flush or do not cover rough wall opening. Provide blank plates for empty boxes.

G. Dimmers:

1. Install dimmers within terms of their listing.
2. Verify that dimmers used for fan speed control are listed for that application.
3. Install unshared neutral conductors on line and load side of dimmers according to manufacturers' device listing conditions in the written instructions.
4. Do not connect dimmers to loads in excess of 80% of the rating of the dimmer.

H. Arrangement of Devices: Unless otherwise indicated, mount flush, with long dimension vertical and with grounding terminal of receptacles on top. Group adjacent switches under single, multigang wall plates.

I. Adjust locations of service poles to suit arrangement of partitions and furnishings.

3.2 GFCI RECEPTACLES

A. Install non-feed-through-type GFCI receptacles where protection of downstream receptacles is not required.

3.3 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

1. Test Instruments: Use instruments that comply with UL 1436.
2. Test Instrument for Convenience Receptacles: Digital wiring analyzer with digital readout or illuminated digital-display indicators of measurement.

B. Tests for Convenience Receptacles:

1. Line Voltage: Acceptable range is 105 to 132 V.
2. Percent Voltage Drop under 15-A Load: A value of 6 percent or higher is unacceptable.
3. Ground Impedance: Values of up to 2 ohms are acceptable.
4. GFCI Trip: Test for tripping values specified in UL 1436 and UL 943.
5. Using the test plug, verify that the device and its outlet box are securely mounted.
6. Tests shall be diagnostic, indicating damaged conductors, high resistance at the circuit breaker, poor connections, inadequate fault current path, defective devices, or similar problems. Correct circuit conditions, remove malfunctioning units and replace with new ones, and retest as specified above.

C. Wiring device will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

END OF SECTION 262726

SECTION 262816 – ENCLOSED SWITCHES

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following:

1. Manual Transfer Switches
2. Generator Connection Enclosures

1.2 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Enclosed switches shall withstand the effects of earthquake motions determined according to ASCE.

1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified."

1.3 ACTION SUBMITTALS

A. Product Data: For each type of enclosed switch, circuit breaker, accessory, and component indicated.

B. Shop Drawings: For enclosed switches and circuit breakers. Include plans, elevations, sections, details, and attachments to other work.

1. Wiring Diagrams: For power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

A. Seismic Qualification Certificates: For enclosed switches and circuit breakers, accessories, and components, from manufacturer.

B. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.6 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Comply with NFPA 70.

PART 2 - PRODUCTS

2.1 MANUAL TRANSFER SWITCHES

A. The manual transfer switch shall be open transition, break-before-make type double throw safety switch. The manual transfer switch shall be heavy duty with a quick make, quick break operating mechanism, with full cover interlock, and indicator handle.

B. The switch shall be rated for the voltage and current and shall have the number of poles indicated on the Plans. Lugs shall be able to accommodate up to 600MCM cabling.

C. The transfer switch shall be listed by UL.

D. Enclosures shall be rated NEMA 12 for indoor use, and NEMA 3R for outdoor use, unless otherwise indicated on the Plans.

E. The manual transfer switch handle shall be padlockable.

F. Manual transfer switches shall be as manufactured by Square D, Eaton, Allen-Bradley, or approved equal.

2.2 GENERATOR CONNECTION ENCLOSURES

A. Provide a 480V, 3-Phase 3-Wire 400A, NEMA 3R enclosure fabricated from galvanized steel and power coated ANSI gray. The enclosure shall have mounting tabs for surface mounting and a drip shield above the door opening. The enclosure shall have a hinged front door provided with a latch that is padlockable.

B. The bottom of the enclosure shall contain a hinged door for the entry of portable cable. The door shall be secured by a latch accessible only from the inside of the enclosure.

C. The conduit entrance shall be through the top or back of the enclosure. Wire terminations for the building wire shall be to mechanical lugs sized for 400A and large enough to accommodate up to 600MCM cabling.

D. A dead front cover shall prevent access to the internal electrical components when the main access door is open.

E. Series 16 Cam inlets shall be mounted on an internal dead front inlet panel and shall accept standard E1016 type connectors. One set of cam inlets rated for up to 400A shall be provided. Cam inlets shall be color coded for phase (brown, orange and yellow) and ground (green).

F. The ground inlet shall be wired to the enclosure frame and a ground connection lug shall be provided for contractor termination of the building ground wire.

G. The internal dead front inlet panel shall contain slots between inlets to eliminate hysteresis, as required by the NEC.

H. A warning label to specify the proper sequence for connection and removal of portable cable as shall be mechanically fastened to front cover of the enclosure.

I. The Generator Connection Box shall meet or exceed all applicable NEC standards and shall be UL Listed. A label denoting the UL Listing shall be permanently affixed to the unit.

J. Generator connection enclosures shall be as manufactured by Union Connector, Lex, or approved equal.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Enclosed switches and generator connection enclosures shall be installed, in accordance with the manufacturers' recommendations.

B. The enclosed switches and generator connection enclosures shall be installed as indicated on the Plans.

C. Provide grounding per NEC.

END OF SECTION 262816

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SECTION 262923 - VARIABLE-FREQUENCY DRIVES

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes separately enclosed, pre-assembled, combination VFDs, rated 600 V and less, for speed control of three-phase, squirrel-cage induction motors.

B. See Section 262419 "Motor-Control Centers" for VFDs installed in motor-control centers.

1.2 DEFINITIONS

A. CE: Conformite Europeene (European Compliance).
B. CPT: Control power transformer.
C. EMI: Electromagnetic interference.
D. IGBT: Insulated-gate bipolar transistor.
E. LAN: Local area network.
F. LED: Light-emitting diode.
G. MCP: Motor-circuit protector.
H. NC: Normally closed.
I. NO: Normally open.
J. OCPD: Overcurrent protective device.
K. PCC: Point of Common Coupling
L. PID: Control action, proportional plus integral plus derivative.
M. PWM: Pulse-width modulated.
N. P&ID: Process & Instrumentation Diagram
O. RFI: Radio-frequency interference.
P. SCADA: Supervisory control and data acquisition.
Q. TDD: Total Demand Distortion
R. THD: Total Harmonic Distortion
S. VFD: Variable-frequency drive.

1.3 PERFORMANCE REQUIREMENTS

A. Seismic Performance: VFDs shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

1.4 ACTION SUBMITTALS

A. Product Data: For each type and rating of VFD indicated.

B. System Harmonics Analysis: For each VFD and for the distribution system as a whole.

C. Shop Drawings: For each VFD indicated. Include dimensioned plans, elevations, and sections; and conduit entry locations and sizes, mounting arrangements, and details, including required clearances and service space around equipment.

1. Show tabulations of installed devices, equipment features, and ratings.
2. Schematic and Connection Wiring Diagrams: For power, signal, communications, and control wiring.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Floor plans, drawn to scale, showing dimensioned layout, required working clearances, and required area above and around VFDs. Show VFD layout and relationships between electrical components and adjacent structural and mechanical elements. Show support locations, type of support, and weight on each support. Indicate field measurements.

B. Seismic Qualification Certificates: For VFDs, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based, and their installation requirements.

C. Product certificates.

D. Source quality-control reports.

E. Field quality-control reports.

1.6 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.7 QUALITY ASSURANCE

A. Testing Agency Qualifications: Member company of NETA or an NRTL.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. Comply with NFPA 70.

D. IEEE Compliance: Fabricate and test VFD according to IEEE 344 to withstand seismic forces defined in Section 260548 "Vibration and Seismic Controls for Electrical Systems."

1.8 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace VFDs that fail in materials or workmanship within specified warranty period.

   1. Warranty Period: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURED UNITS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   1. Rockwell Automation, Inc.; Allen-Bradley PowerFlex 700 series drives.
   2. Schneider Electric, Inc.; Altivar Process 630 series drives.
   3. Eaton SVX/SPX9000 series drives.

B. General Requirements for VFDs: Comply with NEMA ICS 7, NEMA ICS 61800-2, and UL 508C.

C. Application: Constant torque and variable torque.

D. VFD Description: Variable-frequency power converter (rectifier, dc bus, and IGBT, PWM inverter) factory packaged in an enclosure, with integral disconnecting means and overcurrent and overload protection; listed and labeled by an NRTL as a complete unit; arranged to provide self-protection, protection, and variable-speed control of one or more three-phase induction motors by adjusting output voltage and frequency.

   1. Units suitable for operation of NEMA MG 1, Design A and Design B motors as defined by NEMA MG 1, Section IV, Part 30, "Application Considerations for Constant Speed Motors Used on a Sinusoidal Bus with Harmonic Content and General Purpose Motors Used with Adjustable-Voltage or Adjustable-Frequency Controls or Both."
   2. Units suitable for operation of inverter-duty motors as defined by NEMA MG 1, Section IV, Part 31, "Definite-Purpose Inverter-Fed Polyphase Motors."
   3. Listed and labeled for integrated short-circuit current (withstand) rating by an NRTL acceptable to authorities having jurisdiction.

E. Design and Rating: Match load type, such as fans, blowers, and pumps; and type of connection used between motor and load such as direct or through a power-transmission connection.

F. Output Rating: Three-phase; 10 to 200 (60 as programmed default) Hz, programmable as voltage proportional to frequency throughout voltage range or with sensorless vector control; maximum voltage equals input voltage.

G. Unit Operating Requirements:

   1. Input AC Voltage Tolerance: Plus 10 and minus 15 percent of VFD input voltage rating.
   2. Input AC Voltage Unbalance: Not exceeding 5 percent.
   3. Input Frequency Tolerance: Plus or minus 3 percent of VFD frequency rating.

4. Minimum Efficiency: 97 percent at 60 Hz, full load.
5. Minimum Displacement Primary-Side Power Factor: 98 percent under any load or speed condition.
6. Minimum Short-Circuit Current (Withstand) Rating: Equal to the rating of the gear feeding the drive. If not listed, 65 kA.
7. Ambient Temperature Rating: Not less than 14 deg F (minus 10 deg C) and not exceeding 122 deg F (50 deg C). This is specifically the requirement for the VFD unit itself and not the overall panel assembly. The overall assembly shall meet the requirements of 260000-1.4-A-8 which requires the overall assembly to operate at an ambient temperature of up to 104°F. Electrical equipment not rated for operation at that temperature shall be provided with air conditioning. The majority of the MCC's for the project are located indoors in air-conditioned rooms which satisfies this requirement. VFD assemblies shall have appropriately designed ventilation and or air conditioning so as to protect the internal components and to keep internal panel temperatures below the internal components' rated temperatures.
8. Ambient Storage Temperature Rating: Not less than minus 4 deg F (minus 20 deg C) and not exceeding 158 deg F (70 deg C)
9. Humidity Rating: Less than 95 percent (noncondensing).
10. Altitude Rating: Not exceeding 3300 feet without de-rating. Up to 9850 feet with de-rating.
11. Vibration Withstand: Comply with IEC 60068-2-6.
12. Overload Capability: VFD system shall be rated for continuous operation at a minimum of 110% of motor load full load amps (FLA) times the motor service factor. Variable torque inverters shall be capable of delivering 110% of continuous rating for a minimum of 60 seconds. Constant torque inverters shall be capable of delivering 150% of continuous rating for a minimum of 60 seconds.
13. Starting Torque: Minimum 100 percent of rated torque from 3 to 60 Hz.
14. Speed Regulation: Plus or minus 0.6 Hz.
15. Output Carrier Frequency: Selectable; 0.5 to 15 kHz.
16. Stop Modes: Programmable; includes fast, free-wheel, and dc injection braking.

H. Inverter Logic: Microprocessor based, VFD isolated from all power circuits.

I. Isolated Control Interface: Allows VFDs to follow remote-control electrical signal over a minimum 100:1 speed range.

J. Internal Adjustability Capabilities:

1. Minimum Speed: 5 to 25 percent of maximum rpm.
2. Maximum Speed: 80 to 100 percent of maximum rpm.
3. Acceleration: 0.1 to 999.9 seconds.
4. Deceleration: 0.1 to 999.9 seconds.
5. Current Limit: 30 to minimum of 150 percent of maximum rating.

K. Self-Protection and Reliability Features:

1. Input transient protection by means of surge suppressors to provide three-phase protection against damage from supply voltage surges 10 percent or more above nominal line voltage.
2. Loss of Input Signal Protection: Selectable response strategy, including speed default to a percent of the most recent speed, a preset speed, or stop; with alarm.

3. Under- and overvoltage trips.
4. Inverter overcurrent trips.
5. VFD and Motor Overload/Overtemperature Protection: Microprocessor-based thermal protection system for monitoring VFDs and motor thermal characteristics, and for providing VFD overtemperature and motor overload alarm and trip; settings selectable via the keypad; NRTL approved.
6. Critical frequency rejection, with three selectable, adjustable deadbands.
7. Instantaneous line-to-line and line-to-ground overcurrent trips.
8. Loss-of-phase protection.
9. Reverse-phase protection.
10. Short-circuit protection.
11. Motor overtemperature fault.

L. Automatic Reset/Restart: Attempt three restarts after drive fault or on return of power after an interruption and before shutting down for manual reset or fault correction; adjustable delay time between restart attempts.

M. Power-Interruption Protection: To prevent motor from re-energizing after a power interruption until motor has stopped, unless "Bidirectional Autospeed Search" feature is available and engaged.

N. Bidirectional Autospeed Search: Capable of starting VFD into rotating loads spinning in either direction and returning motor to set speed in proper direction, without causing damage to drive, motor, or load.

O. Torque Boost: Automatically varies starting and continuous torque to at least 1.5 times the minimum torque to ensure high-starting torque and increased torque at slow speeds.

P. Motor Temperature Compensation at Slow Speeds: Adjustable current fall-back based on output frequency for temperature protection of self-cooled, fan-ventilated motors at slow speeds.

Q. Integral Input Disconnecting Means and OCPD: NEMA AB 1, thermal-magnetic circuit breaker with pad-lockable, door-mounted handle mechanism.

1. Disconnect Rating: Not less than 115 percent of VFD input current rating.
2. Disconnect Rating: Not less than 115 percent of NFPA 70 motor full-load current rating or VFD input current rating, whichever is larger.

2.2 CONTROLS AND INDICATION

A. Status Lights: Door-mounted LED indicators displaying the following conditions:

1. Power on.
2. Run.
3. VFD Fault.
4. All other lights as shown on the design drawings

B. Panel-Mounted Operator Station: Manufacturer's standard front-accessible, sealed keypad and plain-English language digital display; allows complete programming, program copying, operating, monitoring, and diagnostic capability.

C. Historical Logging Information and Displays:

1. Running log of total power versus time.
2. Total run time.
3. Fault log, maintaining last four faults with time and date stamp for each.

D. Indicating Devices: Digital display mounted flush in VFD door and connected to display VFD parameters including, but not limited to:

1. Output frequency (Hz).
2. Motor speed (rpm).
3. Motor status (running, stop, fault).
4. Motor current (amperes).
5. Motor torque (percent).
6. Fault or alarming status (code).
7. PID feedback signal (percent).
8. DC-link voltage (V dc).
9. Set point frequency (Hz).
10. Motor output voltage (V ac).

E. Control Signal Interfaces:

1. Electric Input Signal Interface:

a. Speed Reference: The VFD drive shall be capable of being controlled locally by a speed potentiometer or remotely by a 4- to 20-mA dc signal. The 4- to 20-mA signal shall be galvanically isolated and input resistance shall not exceed 250 ohms.

b. A minimum of two programmable analog inputs shall be provided and would be typically used for PID process variable and set point. These signals shall be setup to accept a 4- to 20-mA dc signal. The 4- to 20-mA signal shall be galvanically isolated and input resistance shall not exceed 250 ohms.

c. A minimum of six multifunction programmable digital inputs. The drive shall be expandable to handle additional digital inputs if required. The digital inputs shall be programmable to perform functions including, but not limited to:

1) VFD Start/Stop Control (2 or 3 wire)
2) Forward/Reverse/Stop Control
3) Local/Remote. The VFD shall be programmable so that “Local” control may either be the keypad or by hard-wired start/stop and potentiometer. The VFD shall be programmable so that “Remote” control may either be hard-wired start/stop and 4- to 20mA speed control or via the communications network.
4) VFD Interlock/Enable. This input when de-energized will not allow the VFD to run the motor under any circumstance.

5) VFD External Fault. This input will trip the VFD and require a reset before allow the motor to run again.
6) Preset Frequencies. The VFD shall be programmable to run at pre-programmed frequencies with up to 6 different steps.

2. Output Signal Interface:

a. A minimum of two programmable analog output signals 4- to 20-mA dc, which can be configured for any of the following:

1) Output frequency (Hz).
2) Output current (load).
3) DC-link voltage (V dc).
4) Motor torque (percent).
5) Motor speed (rpm).
6) Set point frequency (Hz).
7) Motor power (kW)

b. A minimum of two programmable dry-circuit relay outputs (120-V ac, 1 A) for remote indication of the following (the drive shall be expandable to handle additional digital outputs if required):

1) Motor running.
2) VFD ready.
3) Set point speed reached.
4) Fault and warning indication (overtemperature or overcurrent).
5) PID high- or low-speed limits reached.

F. PID Control Interface: Provides closed-loop set point, differential feedback control in response to dual feedback signals. Allows for closed-loop control of fans and pumps for pressure, flow, or temperature regulation.

1. Number of Loops: One.

G. SCADA Interface: Factory-installed hardware and software to enable the SCADA to monitor, control, and display VFD status and alarms and energy usage. Allows VFD to be used with an external system within a multidrop LAN configuration; settings retained within VFD's nonvolatile memory.

1. Network Communications Ports: Ethernet
2. SCADA Protocols for Network Communications: Ethernet/IP protocol accessible via the communications ports.

2.3 LINE CONDITIONING AND FILTERING

A. Input Line Conditioning: All new power distribution systems supplied shall be required to meet the requirements of IEEE 519-1992. Specifically, the system shall adhere to the TDD requirements of Table 10-3 of IEEE 519-1992. If the power distribution system is equipped with an Active Harmonic System, each VFD shall be equipped with a line reactor whose impedance is as recommended by the Active Harmonic System manufacturer (typically 3%). If no Active Harmonic System is part of the power distribution system, the following rules as a minimum shall define the input line conditioning for each VFD (unless further conditioning is required to meet the IEEE 519-1992 limits). With the Engineer's approval, the contractor may decide to supply an Active Harmonic System even if not shown on the drawings, with corresponding reactors and chokes (this would typically occur if it is more cost effective to meet IEEE 519 with a single system then multiple harmonic filters).

1. All VFD's sized for motors 50HP or larger shall be equipped with DC-link chokes.
2. All VFD's sized for motors 40HP and less shall be equipped with 5% line reactors unless specifically called out as otherwise on the drawings.
3. All VFD's sized for 50HP to 200HP motors shall be equipped with passive harmonic filters with DC Link Chokes.
4. All VFD's greater than 200HP shall have be setup to have less than 5% THD for both voltage and current. This would typically require that the drive is setup with an 18-pulse front end or with an active harmonic filter. The VFD assembly shall accept a single 3-phase input and shall contain all of the harmonic mitigation equipment as part of the assembly.

B. EMI/RFI Filtering: VFD's shall be CE marked and certify compliance with IEC 61800-3 for Category C2.

2.4 LOAD CONDITIONING

A. Load Conditioning: For VFD driven loads with conductor lengths between 200 and 1,000 feet, output dV/dt filters shall be provided as part of the VFD assembly. It is strongly recommended that VFD motor leads not be longer than 500 feet and alternative VFD locations should be considered. If absolutely necessary, loads with conductor lengths greater than 1,000 feet shall have output sine wave filters shall be provided as part of the VFD assembly. Voltage drop considerations shall be taken into account when selecting the motor's nameplate voltage.

2.5 LINE AND LOAD CONDITIONING EQUIPMENT

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. MTE Corporation.
2. Transcoil International (TCI).
3. Or approved equal.

B. Line Reactors: Reactors shall be part of the VFD assembly. They shall be sized based upon the VFD input power requirements. They shall be properly installed with appropriate spacing and ventilation for ambient temperatures up to 104°F. The reactor shall meet the following criteria:

1. The reactor shall be UL 508 listed.
2. Continuous current rating: 100% RMS.
3. Intermittent current ratings: 150% for 60 seconds; 200% for 10 seconds.
4. Altitude Rating: Not exceeding 3300 feet without de-rating. Up to 9850 feet with de-rating.
5. All wiring shall be copper.

C. Passive Harmonic Filters: Filters shall be part of the VFD assembly. They shall be sized based upon the VFD input power requirements. They shall be properly installed with appropriate spacing and ventilation for ambient temperatures up to 104°F. The filter shall meet the following criteria:

1. The filter shall be UL 508 listed.
2. The filter shall filter harmonics generated by the nonlinear VFD to satisfy the requirements of IEEE 519-1992 for individual and total harmonic voltage and current distortion at the input terminals of the filter.
3. The TDD of the current at the input terminals of the filter shall not exceed the limits defined in Table 10-3 of IEEE 519-1992.
4. Full load efficiency: 97% or greater
5. The filter shall not resonate with the power distribution system nor attract harmonics from other sources.
6. The harmonic filter shall be a passive series connected low pass filter consisting of an inductor capacitor network. Active electronic components shall not be used.
7. The harmonic filter shall be equipped with a contactor that will connect the capacitor(s) only when the motor is running, avoiding nuisance VFD over-voltage tripping.
8. All wiring shall be copper.

D. dV/dt Filters: Filters shall be part of the VFD assembly. They shall be sized based upon motor horsepower and required full-load current (including service factor). They shall be properly installed with appropriate spacing and ventilation for ambient temperatures up to 104°F. The filter shall meet the following criteria:

1. The filter shall be UL 508 listed.
2. Maximum peak motor terminal voltage with 500 feet of cable: 15% of bus voltage.
3. Maximum dV/dt: 200 Volts per microsecond.
4. The dV/dt Filter shall reduce common mode voltages by a minimum of 40%.
5. Continuous current rating: 100% RMS.
6. Intermittent current ratings: 150% for 60 seconds; 200% for 10 seconds.
7. Allowed inverter switching frequencies: 1kHz to 8 kHz.
8. Nominal inverter operating frequency: 60Hz; Minimum – 6 Hz; Maximum with de-rating: 120Hz.
9. Altitude Rating: Not exceeding 3300 feet without de-rating. Up to 9850 feet with de-rating.
10. Insertion loss: 3% of rated voltage maximum.
11. All wiring shall be copper.

E. Sine Wave Filters: Filters shall be part of the VFD assembly. They shall be sized based upon motor horsepower and required full-load current (including service factor). They shall be properly installed with appropriate spacing and ventilation for ambient temperatures up to 104°F. The filter shall meet the following criteria:

1. The filter shall be UL 508 listed.
2. Harmonic Voltage Distortion: 10% maximum
3. Continuous current rating: 100% RMS.
4. Intermittent current rating: 150% for 60 seconds.
5. Allowed inverter switching frequencies: 2kHz to 8 kHz.
6. Nominal inverter operating frequency: 60Hz; Minimum – 0 Hz; Maximum with de-rating: 90Hz.

7. The Sine Wave Filter shall reduce common mode voltages by a minimum of 40%.
8. Altitude Rating: Not exceeding 3300 feet without de-rating. Up to 9850 feet with de-rating.
9. Insertion loss: 6% of rated voltage maximum.
10. All wiring shall be copper.

2.6 BYPASS SYSTEMS

A. Provide Bypass Systems only if indicated on the drawings.

B. Bypass Operation: Safely transfers motor between power converter output and bypass circuit, manually, automatically, or both. Selector switches set modes and indicator lights indicate mode selected. Unit is capable of stable operation (starting, stopping, and running) with motor completely disconnected from power converter.

C. Bypass Mode: Field-selectable automatic or manual, allows local and remote transfer between power converter and bypass contactor and retransfer, either via manual operator interface or automatic control system feedback.

D. Bypass Controller: Two-contactor-style bypass allows motor operation via the power converter or the bypass controller; with input isolating switch and barrier arranged to isolate the power converter and permit safe troubleshooting and testing, both energized and de-energized, while motor is operating in bypass mode.

1. Bypass Contactor: Load-break, NEMA-rated contactor.
2. Output Isolating Contactor: Non-load-break, NEMA-rated contactor.
3. Isolating Switch: Non-load-break switch arranged to isolate power converter and permit safe troubleshooting and testing of the power converter, both energized and de-energized, while motor is operating in bypass mode; pad-lockable, door-mounted handle mechanism.

E. Bypass Contactor Configuration: Full-voltage (across-the-line) or reduced voltage soft-starter as shown on the drawings.

1. NORMAL/BYPASS selector switch.
2. HAND/OFF/AUTO selector switch.
3. NORMAL/TEST Selector Switch: Allows testing and adjusting of VFD while the motor is running in the bypass mode.
4. Contactor Coils: Pressure-encapsulated type with coil transient suppressors.

   a. Operating Voltage: Depending on contactor NEMA size and line-voltage rating, manufacturer's standard matching control power or line voltage.
   b. Power Contacts: Totally enclosed, double break, and silver-cadmium oxide; assembled to allow inspection and replacement without disturbing line or load wiring.

5. Control Circuits: 120-V ac; obtained from integral CPT, with primary and secondary fuses, with CPT of sufficient capacity to operate all integral devices and remotely located pilot, indicating, and control devices.

a. CPT Spare Capacity: 100 VA.

6. Overload Relays: NEMA ICS 2.

2.7 ENCLOSURES

A. VFD Enclosures: NEMA 250, to comply with environmental conditions at installed location.

1. Dry, Clean and Non-corrosive Indoor Locations: Type 1.
2. Outdoor or Corrosive Locations: Type 4X, stainless steel.
3. Wash-Down Areas: Type 4X, stainless steel.
4. Other Wet or Damp Indoor Locations: Type 4.
5. Indoor Locations Subject to Dust, Falling Dirt, and Dripping Noncorrosive Liquids: Type 12.

B. Plenum Rating: UL 1995; NRTL certification label on enclosure, clearly identifying VFD as "Plenum Rated."

2.8 ACCESSORIES

A. General Requirements for Control-Circuit and Pilot Devices: NEMA ICS 5; factory installed in VFD enclosure cover unless otherwise indicated.

1. Push Buttons, Pilot Lights, and Selector Switches: Heavy-duty, oiltight type.

a. Push Buttons: Maintained and/or momentary as required.
b. Pilot Lights: LED types; colors as shown on P&ID's; push to test.
c. Selector Switches: Rotary type.

B. Bypass contactor auxiliary contact(s) as required.

C. Control Relays: Auxiliary and adjustable solid-state time-delay relays.

D. Phase-Failure, Phase-Reversal, and Undervoltage and Overvoltage Relays: Solid-state sensing circuit with isolated output contacts for hard-wired connections. Provide adjustable undervoltage, overvoltage, and time-delay settings.

1. Current Transformers: Continuous current rating, basic impulse insulating level (BIL) rating, burden, and accuracy class suitable for connected circuitry. Comply with IEEE C57.13.

E. Supplemental Analog Meters:

1. Elapsed time meter.

F. Breather and drain assemblies, to maintain interior pressure and release condensation in NEMA 250, Type 4, 4X, and 12 enclosures installed outdoors or in unconditioned interior spaces subject to humidity and temperature swings.

G. Space heaters, with NC auxiliary contacts, to mitigate condensation in NEMA 250, Type 4, 4X, 12 enclosures installed outdoors or in unconditioned interior spaces subject to humidity and temperature swings.

H. Cooling Fan and Exhaust System: For NEMA 250, maintaining enclosure NEMA rating; UL 508 component recognized: Supply fan, with non-corrosive intake and exhaust grills and filters; 120-V ac; obtained from integral CPT.

I. Air Conditioning System: For NEMA 250, maintaining enclosure NEMA rating; UL 508 component recognized; sized to maintain internal temperatures at or below 100°F.

2.9 SOURCE QUALITY CONTROL

A. Testing: Test and inspect VFDs according to requirements in NEMA ICS 61800-2.

1. Test each VFD while connected to its specified motor.
2. Verification of Performance: Rate VFDs according to operation of functions and features specified.

B. VFDs will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Wall-Mounting Controllers: Install VFDs on walls with tops at uniform height and with disconnect operating handles not higher than 79 inches above finished floor unless otherwise indicated, and by bolting units to wall or mounting on lightweight structural-steel channels bolted to wall. For controllers not on walls, provide freestanding racks complying with Section 260529 "Hangers and Supports for Electrical Systems."

B. Seismic Bracing: Comply with requirements specified in Section 260548 "Vibration and Seismic Controls for Electrical Systems."

C. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.

D. Install fuses in each fusible-switch VFD.

E. Install fuses in control circuits if not factory installed. Comply with requirements in Section 262813 "Fuses."

F. Install heaters in thermal-overload relays. Select heaters based on actual nameplate full-load amperes after motors have been installed.

G. Install, connect, and fuse thermal-protector monitoring relays furnished with motor-driven equipment.

H. Comply with NECA 1.

3.2 IDENTIFICATION

A. Identify VFDs, components, and control wiring. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

1. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs.
2. Label each VFD with engraved nameplate.
3. Label each enclosure-mounted control and pilot device.

3.3 CONTROL WIRING INSTALLATION

A. Install wiring between VFDs and remote devices and facility's central-control system. Comply with requirements in Section 260523 "Control-Voltage Electrical Power Cables."

B. Bundle, train, and support wiring in enclosures.

C. Connect selector switches and other automatic control devices where applicable.

1. Connect selector switches to bypass only those manual- and automatic control devices that have no safety functions when switches are in manual-control position.
2. Connect selector switches with control circuit in both manual and automatic positions for safety-type control devices such as low- and high-pressure cutouts, high-temperature cutouts, and motor overload protectors.

3.4 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Perform tests and inspections.

C. Acceptance Testing Preparation:

1. Test insulation resistance for each VFD element, bus, component, connecting supply, feeder, and control circuit.
2. Test continuity of each circuit.

D. Tests and Inspections:

1. Inspect VFD, wiring, components, connections, and equipment installation.
2. Test insulation resistance for each VFD element, component, connecting motor supply, feeder, and control circuits.
3. Test continuity of each circuit.
4. Verify that voltages at VFD locations are within 10 percent of motor nameplate rated voltages. If outside this range for any motor, notify Engineer before starting the motor(s).
5. Test each motor for proper phase rotation.

6. Perform each electrical test and visual and mechanical inspection stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
7. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
8. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.
9. Perform voltage and current harmonic test with each VFD running at minimum and maximum speed. Submit test results for each VFD. Testing shall be witnessed by the Owner and the Engineer.

E. VFDs will be considered defective if they do not pass tests and inspections.

F. Prepare test and inspection reports, including a certified report that identifies the VFD and describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations made after remedial action.

3.5 ADJUSTING

A. Program microprocessors for required operational sequences, status indications, alarms, event recording, and display features. Clear events memory after final acceptance testing and prior to Substantial Completion.

B. Set field-adjustable switches, auxiliary relays, time-delay relays, timers, and overload-relay pickup and trip ranges.

C. Adjust the trip settings of MCPs and thermal-magnetic circuit breakers with adjustable, instantaneous trip elements. Initially adjust to six times the motor nameplate full-load amperes and attempt to start motors several times, allowing for motor cool-down between starts. If tripping occurs on motor inrush, adjust settings in increments until motors start without tripping. Do not exceed eight times the motor full-load amperes (or 11 times for NEMA Premium Efficient motors if required). Where these maximum settings do not allow starting of a motor, notify Engineer before increasing settings.

D. Set field-adjustable circuit-breaker trip ranges as specified in Section 260573 "Overcurrent Protective Device Coordination Study."

3.6 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, reprogram, and maintain VFDs. A minimum of 4 hours of training shall be provided. The training shall cover VFD theory of operation, features and functions available, normal operation, troubleshooting, and routine maintenance. The Contractor shall submit a syllabus for the training session for approval, within 3 weeks of conducting the class. Provide each attendee with a class syllabus detailing each topic to be discussed.

3.7 SPARE PARTS

A. The following spare parts shall be supplied with each type, or frame size, of VFD:

1. 3 sets of all replaceable fuses
2. 3 spare air conditioner or fan filters

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SECTION 264313 - TRANSIENT-VOLTAGE SUPPRESSION FOR LOW-VOLTAGE ELECTRICAL POWER CIRCUITS

PART 1 - Class C Main Entrance Panel Surge Suppression Device

1.1 DESCRIPTION

A. This Section describe the electrical and mechanical requirements for a high energy surge protective device. The specified surge protective device shall provide effective high energy surge diversion for application in ANSI/IEEE C62.41-1991 Location Category C3 environments. Testing per ANSI/IEEE C62.45-1992 using ANSI/IEEE C62.41 Category C3 waveforms and amplitudes. UL 1449 third edition listed. The specified surge protective device shall provide:

1. 200,000 transient amps, per phase, of surge protection.
2. Protection modes: L-N, L-G, L-L, N-G.
3. Green, power present LED on front panel.
4. Remote alarms relay contact.

1.2 STANDARDS

A. The specified device shall be designed, manufactured, tested and installed in compliance with:

1. American National Standards Institute and Institute of Electrical and Electronic Engineers (ANSI/IEEE C62.11, C62.41, and C62.45)
2. Federal Information Processing Standards Publication 94 (FIP PUB 94)
3. National Electrical Manufacturer Association (NEMA LS-1)
4. National Fire Protection Association (NFPA 20, 70, 75 and 78)
5. Underwriters Laboratories (UL 1449 third edition) listed
6. CAN/C22.2 No. 8-M1986; CSA Electrical Certification Notice No. 516

B. The system individual units shall be UL listed under UL 1449 Third Edition Standard for Surge Protective Devices (SPD's) and the surge ratings shall be permanently affixed to the SPD.

1.3 ENTRANCE PANEL EQUIPMENT ELECTRICAL REQUIREMENTS

A. Environmental Requirements:

1. Operating Temperature: Operating temperature range shall be -40 to +140 degrees F
2. Storage Temperature: Storage temperature range shall be -40 to +185 degrees F
3. Relative Humidity: Operation shall be reliable in an environment with 0% to 95% non-condensing relative humidity.
4. Operating Altitude: The system shall be capable of operation up to an altitude of 11,000 feet above sea level.
5. Operating Voltage: Maximum continuous operating voltage shall be 115% of the nominal rated line voltage.
6. Power Frequency: The operating frequency shall be 50/60 Hz.

B. Electrical Requirements:

1. Unit Operating Voltage: The nominal unit operating voltage shall be as indicated Table I below:

Table I

Voltage Description	Surge Current Per Phase	Vpeak L-N	Vpeak L-G	Vpeak L-L	Vpeak N-G	I_n	MCOV
120T 120/240 VAC 1ph, 3W + gnd	200kA	700V	700V	1200V	700V	20kA	150V
120Y 120/208 VAC 3ph, 4W + gnd, wye	200kA	700V	700V	1200V	700V	20kA	150V
220Y 220/380 VAC 3ph, 4W + gnd, wye	200kA	1200V	1200V	2000V	1200V	20kA	320V
240D 240 VAC 3ph, 3W + gnd, delta	200kA	N/A	1000V	1000V	N/A	20kA	320V
240DCT* 240/120/120 3ph, 4W + gnd, hi-leg	200kA	700V 1200V**	700V 1000V**	1200V 1500V**	700V	20kA	150V
240Y 240/415 VAC 3ph, 4W + gnd, wye	200kA	1200V	1200V	2000V	1200V	20kA	320V
277Y 277/480 VAC 3ph, 4W + gnd, wye	200kA	1200V	1200V	2000V	1200V	20kA	320V
480D 480 VAC 3ph, 3W + gnd,delta	200kA	N/A	2500V	2500V	N/A	20kA	640V

*High-leg delta center tapped **Hi-leg

2. Unit shall be installed in parallel with the protected equipment.
3. Contractor is responsible for determining the correct voltage configuration and selecting the SPD for that configuration.
4. Protection per mode shall be: L-N 100kA, L-G 100kA, L-L 200kA, N-G 100kA.
5. The maximum surge current capacity per phase of the specified system, based on the standard IEEE 8/20 microsecond waveform, shall be at least: 1 Event at 150 kA. The surge life (8/20) shall be at least 10,000 occurrences at 6 kA. The surge protective capability shall be bi-directional and suppress both positive and negative impulses.
6. The device shall be designed so as to minimize the internal surge path impedance. Direct point-to-point internal wiring is inherently inductive and not acceptable. Connection to the power service shall be constructed as shown in the installation notes for best performance.
7. Equipment shall be as manufactured by MCG Electronics, Ditek, Square D, Eaton or approved equal with supporting test data

1.4 ENTRANCE PANEL PROTECTION SYSTEM COMPONENTS

A. Diagnostics: Green solid state LED indicators, per phase, shall be provided on the front cover to indicate protection status. Illuminated green LED's indicate full protection is present at the protector, and an extinguished LED shall indicate a reduction in protection on that phase.

B. NEMA 1, 12, 3R, 4, or 4X Enclosure as indicated on the Contract Drawings: Minimum 18 gauge steel. If no NEMA rating indicated on the Contract Drawings, the NEMA rating shall match or be better than the NEMA rating of the equipment the is protected by the SPD.

1.5 INSTALLATION AND MAINTENANCE

A. The unit shall be installed in accordance with the manufacturer's printed instruction to maintain warranty. All local and national codes must be observed.

B. Units shall be installed as close as possible to the panel board to which it is connected. Lead length shall be less than 18 inches.

C. Detailed maintenance instructions shall be printed on the front panel to insure safety of maintenance personnel.

1.6 WARRANTY

A. Manufacturer to provide 10 year warranty to cover repair or replacement with a new device from date of substantial completion.

PART 2 - Class B Branch Panel Surge Protective Device

2.1 DESCRIPTION

A. These specifications describe the electrical and mechanical requirements for a high energy surge protective device. The specified surge protective device shall provide effective high energy surge diversion for application in ANSI/IEEE C62.41-1991 Location Category B3 environments. Testing per ANSI/IEEE C62.45-1992 using ANSI/IEEE C62.41 Category B3 waveforms and amplitudes. UL 1449 third edition listed. The specified surge protective device shall provide:

1. 150,000 transient amps, per phase, of surge protection.
2. Protection modes: L-N, L-G, L-L, N-G.
3. Green, power present LED, one per phase, on front panel.
4. Remote alarm relay contacts, Form C.

2.2 STANDARDS

A. The specified device shall be designed, manufactured, tested and installed in compliance with:

1. American National Standards Institute and Institute of Electrical and Electronic Engineers (ANSI/IEEE C62.11, C62.41, and C62.45)
2. Federal Information Processing Standards Publication 94 (FIP PUB 94)
3. National Electrical Manufacturer Association (NEMA LS-1)
4. National Fire Protection Association (NFPA 20, 70, 75 and 78)
5. Underwriters Laboratories (UL 1449 third edition) listed
6. CAN/C22.2 No. 8-M1986; CSA Electrical Certification Notice No. 516

B. The system individual units shall be UL listed under UL 1449 Third Edition Standard for Surge Protective Devices (SPD's) and the surge ratings shall be permanently affixed to the SPD.

2.3 BRANCH PANEL EQUIPMENT ELECTRICAL REQUIREMENTS

A. Environmental Requirements:

1. Operating Temperature: Operating temperature range shall be -40 to +140 degrees F
2. Storage Temperature: Storage temperature range shall be -40 to +185 degrees F
3. Relative Humidity: Operation shall be reliable in an environment with 0% to 95% non-condensing relative humidity.
4. Operating Altitude: The system shall be capable of operation up to an altitude of 11,000 feet above sea level.
5. Operating Voltage: Maximum continuous operating voltage shall be 115% of the nominal rated line voltage.
6. Power Frequency: The operating frequency shall be 50/60 Hz.

B. Electrical Requirements:

1. Unit Operating Voltage: The nominal unit operating voltage shall be as indicated Table II below:

Table II

Voltage Description	**Surge Current Per Phase**	**Vpeak L-N**	**Vpeak L-G**	**Vpeak L-L**	**Vpeak N-G**	**I_n**	**MCOV**
120T 120/240 VAC 1ph, 3W + gnd	150kA	700V	700V	1200V	700V	20kA	150V
120Y 120/208 VAC 3ph, 4W + gnd, wye	150kA	700V	700V	1200V	700V	20kA	150V
220Y 220/380 VAC 3ph, 4W + gnd, wye	150kA	1200V	1200V	2000V	1200V	20kA	320V
240D 240 VAC 3ph, 3W + gnd, delta	150kA	N/A	1000V	1000V	N/A	20kA	320V
240DCT* 240/120/120 3ph, 4W + gnd, hi-leg	150kA	700V 1200V**	700V 1000V**	1200V 1500V**	700V	20kA	150V
240Y 240/415 VAC 3ph, 4W + gnd, wye	150kA	1200V	1200V	2000V	1200V	20kA	320V
277Y 277/480 VAC 3ph, 4W + gnd, wye	150kA	1200V	1200V	2000V	1200V	20kA	320V
480D 480 VAC 3ph, 3W + gnd,delta	150kA	N/A	2500V	2500V	N/A	20kA	640V

*High-leg delta center tapped **High-Leg

2. Unit shall be installed in parallel with the protected equipment. No series connected protective elements shall be used.
3. Contractor is responsible for determining the correct voltage configuration and selecting the SPD for that configuration.

4. Protection per mode shall be: L-N 75kA, L-G 75kA, L-L 150 kA, N-G 75 kA.
5. The maximum surge current capacity per phase of the specified system, based on the standard IEEE 8/20 microsecond waveform, shall be at least: 1 Event at 100 kA. The surge life (8/20) shall be at least 10,000 occurrences at 4 kA. The surge protection capability shall be bi-directional and suppress both positive and negative impulses.
6. The device shall be designed so as to minimize the internal surge path impedance. Direct point-to-point internal wiring is inherently inductive and not acceptable. Connection to the power service shall be constructed as shown in the installation notes for best performance.
7. Equipment shall be as manufactured by MCG Electronics, Ditek, Square D, Eaton or approved equal with supporting test data.

2.4 BRANCH PANEL PROTECTION SYSTEM COMPONENTS

A. Diagnostics: One green solid state LED indicators, per phase, shall be provided on the front cover to indicate protection status. Illuminated green LED's indicate full protection is present at the protector, and an extinguished LED shall indicate a reduction in protection on that phase.

B. NEMA 1, 12, 3R, 4, or 4X Enclosure as indicated on drawings: Minimum 18gauge steel. If no NEMA rating indicated on the Contract Drawings, the NEMA rating shall match or be better than the NEMA rating of the equipment the is protected by the SPD.

2.5 INSTALLATION AND MAINTENANCE

A. The unit shall be installed in accordance with the manufacturer's printed instruction to maintain warranty. All local and national codes must be observed.

B. Units shall be installed as close as possible to the panel board to which it is connected. Lead length shall be less than 18 inch.

C. Detailed maintenance instructions shall be printed on the front panel to insure safety of maintenance personnel.

2.6 WARRANTY

A. Manufacturer to provide 10 year warranty to cover repair or replacement with a new device from date of substantial completion.

PART 3 - Class A Local Panel / Control Panel Surge Device

3.1 DESCRIPTION

A. These specifications describe the electrical and mechanical requirements for a shunt installed AC power line surge device. The specified surge protective device shall provide effective energy surge diversion for application in ANSI/IEEE C62.41-1991 Location Category B3 environments. Testing per ANSI/IEEE C62.45-1992 using ANSI/IEEE C62.41 Category B3 waveforms and amplitudes. UL 1449 third edition listed. The specified surge protective device shall provide:

1. 50,000 transient amps, per phase, of surge protection.

2. Protection modes: L-N, L-G, L-L, N-G
3. Green, power present LED, red, protection reduced LED on front panel.

3.2 STANDARDS

A. The specified device shall be designed, manufactured, tested and installed in compliance with:

4. American National Standards Institute and Institute of Electrical and Electronic Engineers (ANSI/IEEE C62.11, C62.41, and C62.45)
5. Federal Information Processing Standards Publication 94 (FIP PUB 94)
6. National Electrical Manufacturer Association (NEMA LS-1)
7. National Fire Protection Association (NFPA 20, 70, 75 and 78)
8. Underwriters Laboratories (UL 1449 third edition) listed
9. CAN/C22.2 No. 8-M1986; CSA Electrical Certification Notice No. 516

The system individual units shall be UL listed under UL 1449 third Edition Standard for Surge Protective Devices (SPD's) and the surge ratings shall be permanently affixed to the SPD.

3.3 LOCAL PANEL EQUIPMENT ELECTRICAL REQUIREMENTS

A. Environmental Requirements:

1. Operating Temperature: Operating temperature range shall be -40 to +140 degrees F
2. Storage Temperature: Storage temperature range shall be -40 to +185 degrees F
3. Relative Humidity: Operation shall be reliable in an environment with 0% to 95% non-condensing relative humidity.
4. Operating Altitude: The system shall be capable of operation up to an altitude of 10,000 feet above sea level.
5. Operating Voltage: Maximum continuous operating voltage shall be 115% of the nominal rated line voltage.
6. Power Frequency: The operating frequency shall be 50/60 Hz.

B. Electrical Requirements:

1. Unit Operating Voltage: The nominal unit operating voltage shall be as indicated in Table III below:

Table III

Voltage Description	**Surge Current Per Phase**	**Vpeak L-N**	**Vpeak L-G**	**Vpeak L-L**	**Vpeak N-G**	**I_n**	**MCOV**
120T 120/240 VAC 1ph, 3W + gnd	50kA	700V	700V	1200V	700V	20kA	150V
120Y 120/208 VAC 3ph, 4W + gnd, wye	50kA	700V	700V	1200V	700V	20kA	150V
220Y 220/380 VAC 3ph, 4W + gnd, wye	50kA	1200V	1200V	2000V	1200V	20kA	320V
240D 240 VAC 3ph, 3W + gnd, delta	50kA	N/A	1000V	1000V	N/A	20kA	320V

240DCT* 240/120/120 3ph, 4W + gnd, hi-leg	50kA	700V 1200V**	700V 1000V**	1200V 1500V**	700V	20kA	150V
240Y 240/415 VAC 3ph, 4W + gnd, wye	50kA	1200V	1200V	2000V	1200 V	20kA	320V
277Y 277/480 VAC 3ph, 4W + gnd, wye	50kA	1200V	1200V	2000V	1200 V	20kA	320V
480D 480 VAC 3ph, 3W + gnd,delta	50kA	N/A	2500V	2500V	N/A	20kA	640V

*High-leg delta center tapped **High-Leg

2. Unit shall be installed in parallel with the protected equipment.
3. Contractor is responsible for determining the correct voltage configuration and selecting the SPD for that configuration.
4. Protection per mode shall be: L-N 25 kA, L-G 25 kA, L-L 50 kA, N-G 25 kA.
5. The maximum surge current capacity per phase of the specified system, based on the standard IEEE 8/20 microsecond waveform, shall be at least: 1 Event at 50 kA, the surge life shall be at least 200 events at 6kA and 20,000 events at 2kA. The surge protection capability shall be bi-directional and suppress both positive and negative impulses.
6. The device shall be designed so as to minimize the internal surge path impedance. Direct point-to-point internal wiring is inherently inductive and not acceptable. Connection to the power service shall be constructed as shown in the installation notes for best performance.
7. Equipment shall be as manufactured by MCG Electronics, Ditek, Square D, Eaton or approved equal with supporting test data.

3.4 LOCAL PANEL PROTECTION SYSTEM COMPONENTS

A. MOVS: The device shall be constructed of multiple 32 mm metal oxide varistors.

B. Self-Diagnostics: Solid state red and green LED indicators shall be provided on the front cover to indicate AC power present at the device and protection status

C. NEMA 1, 12, 3R, 4, or 4X enclosure as indicated on the drawings: Minimum 18 gauge steel provided with mounting flanges. If no NEMA rating indicated on the Contract Drawings, the NEMA rating shall match or be better than the NEMA rating of the equipment the is protected by the SPD.

3.5 INSTALLATION AND MAINTENANCE

A. The unit shall be installed in accordance with the manufacturer's printed instruction to maintain warranty. All local and national codes must be observed.

B. Units shall be installed as close as possible to the panelboard to which it is connected. Lead length shall be less than 18 inches.

C. Detailed maintenance instructions shall be printed on the front panel to insure safety of maintenance personnel.

3.6 WARRANTY

A. Manufacturer to provide 10 year warranty to cover repair or the providing of a new device from date of substantial completion.

PART 4 - Class A Surge Suppression Device installed within Protected Equipment

4.1 DESCRIPTION

A. These specifications describe the electrical and mechanical requirements for a series installed AC power line surge protective device. The specified surge protective device shall proved effective energy surge diversion for application in ANSI/IEEE C62.41-1991 Location Category A3 environments. Testing per ANSI/IEEE C62.45-1992 using ANSI/IEEE C62.41 Category A3 waveforms and amplitudes. UL 1449 recognized. The specified surge protective device shall provide:

1. 10,000 transient amps of surge protection.
2. L-N, L-G, H-G protected modes.
3. Green protection present LED.
4. EMI-RFI Filter.
5. Low profile construction.

4.2 STANDARDS

A. The specified device shall be designed, manufactured, tested and installed in compliance with:

1. American National Standards Institute and Institute of Electrical and Electronic Engineers (ANSI/IEEE C62.11, C62.41, and C62.45)
2. Federal Information Processing Standards Publication 94 (FIP PUB 94)
3. National Fire Protection Association (NFPA 20, 70, 75 and 78)
4. Underwriters Laboratories (UL Second Edition 1449 Recognized)
5. National Electrical Manufacturer Association (NEMA LS-1)
6. CAN/C22.2 No. 8-M1986; CSA Electrical Certification Notice No. 516

B. The system individual units shall be UL recognized under UL 1449 third Edition Standard for Surge Protective Device (SPD).

1.3 LOCAL EQUIPMENT ELECTRICAL REQUIREMENTS

A. Environmental Requirements:

1. Operating Temperature: Operating temperature range shall be –40 to +140 degrees F.
2. Storage Temperature: Storage temperature range shall be –40 to +185 degrees F.
3. Relative Humidity: Operating shall be reliable in an environment with 0% to 95% non-condensing relative humidity.
4. Operating Altitude: The system shall be capable of operation up to an altitude of 13,000 feet above sea level.
5. Operating Voltage: Maximum continuous operating voltage shall be 115% of the

nominal rated line voltage.

6. Power Frequency: The power frequency range shall be 50-400 Hertz.

1.4 Electrical Requirements:

A. Unit Operating Voltage: The nominal unit operating voltage shall be as indicated in Table IV below.

Table IV

Voltage / Description	**Joules 8/20us**	**Clamp @ 1mA**	**V Peak L - N**
120 VAC 1phase, 2W + G	500	220V	392V
240 VAC 1phase, 2W + G	900	425V	760V

B. Unit shall be installed in series or in parallel with the protected equipment.

C. The maximum surge current capacity per phase of the specified system, based on the standard IEEE 8/20 microsecond waveform, shall be at least: 1 Event at 10 kA. The surge life (8/20us) shall be at least 10,000 occurrences at 500A. The surge protection capability shall be by-directional and suppress both positive and negative impulses.

D. The device shall be designed so as to minimize the internal surge path impedance. Direct point-to-point internal wiring is inherently inductive and not acceptable. Connection to the power service shall be constructed as shown in the installation notes for best performance.

E. Equipment shall be as manufactured by MCG Electronics, Ditek, Transector or approved equal with supporting test data.

F. The device shall contain a common mode noise filter with specifications as in Table V below:

Table V

Filter Attenuation (50 ohm)	**Frequency**
-20db	45 kHz
-30db	75 kHz
-40db	150 kHz
-50db	250 kHz
-60db	450 kHz

4.5 EQUIPMENT LEVEL PROTECTION SYSTEM COMPONENTS

A. MOVS: The device shall be constructed of multiple metal oxide varistors.

B. Self-Diagnostics: An illuminated green solid state LED indicator shall be provided on the front cover to indicate protection is present at the device.

C. Connection: Solderless Screw Terminals or hard wired leads less than 12 inches.

D. Enclosure: High-impact plastic.

4.6 INSTALLATION AND MAINTENANCE

A. The unit shall be installed in accordance with the manufacturer's printed instruction to maintain warranty. All local and national codes must be observed.

B. Units shall be installed within the equipment to which it is connected.

4.7 WARRANTY

A. Manufacturer to provide 10 year warranty to cover repair or replacement with a new device.

END OF SECTION 264313

SECTION 265000 – LIGHTING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Interior lighting fixtures, lamps, and ballasts.
2. Emergency lighting units.
3. Exit signs.

1.2 SCOPE OF WORK

A. The Contractor shall provide all labor, materials, equipment and incidentals as shown, specified and required to furnish and install lighting fixtures.

1.3 QUALITY ASSURANCE

A. Reference Standards:

1. National Electrical Code (NEC)
2. UL Standard #57, Electric Lighting Fixtures
3. UL Standard #844, Electric Lighting Fixtures for Use in Hazardous Location
4. UL Standard #1570, Fluorescent Lighting Fixtures
5. UL Standard #1571, Incandescent Lighting Fixtures
6. UL Standard #1572, High Intensity Discharge Lighting Fixtures
7. Illuminating Engineering Society (IES)
8. All applicable local lighting ordinances

B. Miscellaneous:

1. Lamps are identified for each luminaire in the Lighting Fixture Schedule on the Plans.
2. Lighting fixtures and electrical components:
   a. UL labeled, complete with lamps.
   b. Rated for area classification as indicated.
      1) All lighting in classified areas are to be of the T3 temperature class unless otherwise indicated, refer to Table 500.8(B) of the NEC.
   c. Lighting shall meet OSHA requirements.
3. On the Plans, the location of lighting fixtures is intended to be used as a guide.
   a. Field conditions may affect actual locations.
   b. Coordinate with other trades to avoid conflicts in mounting of fixtures and other equipment.
4. The quality standard is established by the fixture listed in the Lighting Fixture Schedule.
   a. This quality standard includes, but is not necessarily limited to construction features, materials of construction, finish, and photometrics.

1.4 SUBMITTALS

A. The following shall be submitted to the Engineer for review:

1. Acknowledgment that products submitted meet requirements of standards referenced.
2. Manufacturer's technical information on products to be used including photometric performance curves for the fixture and ballast data.
3. Acknowledgment that products submitted are UL listed.
4. When general data sheets constitute part of the submittal, identify the products to be used on this project.
5. Manufacturer's installation instructions.
6. Identification of fixtures by Lighting Fixture Schedule.
7. UL nameplate data (Voltage, wattage, etc.).
8. Finishes, colors, and mounting type.
9. Pole, fixture, and accessories.
10. Pole wind loading.

B. Contractor shall submit shop drawings, manufacturer's data sheets, and a complete wiring diagram detailing all connections to the electrical system in accordance with Section 013300 "Contractor Submittals" and Section 260000 "General Electrical Requirements.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Lamps shall be manufactured by:

1. General Electric
2. North American/Phillips
3. Sylvania
4. Approved equal.

B. Lighting fixtures shall be provided as indicated on the Lighting Fixture Schedule on the Plans.

C. Lighting ballasts shall be manufactured by:

1. General Electric
2. Advance
3. Jefferson
4. Universal
5. Bodine
6. Lithonia
7. Approved equal

D. Light poles shall be as indicated on the Plans. Include base template, anchor bolts, cadmium-plated hardware and pole grounding lug, hand-hole, anchor base and bolt covers. Pole foundations shall be as indicated on the Plans.

2.2 MATERIALS

A. General:

1. Lamps:
   a. See lighting fixture schedule on Plans for wattage, voltage and number required.
2. All Fixtures:
   a. There shall be no live parts normally exposed to contact.
   b. When intended for use in wet area:
      1) Mark fixtures “suitable for wet locations.”
   c. When intended for use in damp areas:
      1) Mark fixtures “suitable for damp locations” or “suitable for wet locations.”
   d. In wet or damp area, install fixtures so that water cannot enter or accumulate in the wiring compartment, lamp-holder, or other electrical parts.
   e. Gasket seals: Urethane foam
   f. Diffusers: UV stabilized acrylic plastic
3. Underground wiring:
   a. Provide all wiring runs with separate green grounding conductor.
   b. Ground all pole bases.
4. Pole wiring from base to ballast:
   a. No. 12 type XHHW.
   b. Each phase shall be protected by a 30A, 600V, type Tron waterproof fuse-holder, Bussman “Limitron” type fuse, size rating 3-times load current.

B. Incandescent Lamps:

1. No incandescent lamps shall be allowed

C. Fluorescent Lamps:

1. Rapid start
2. Cool white (F32T8/41K-85CRI and F96T12/41K-70CRI/HO/ES)
3. Energy efficient or standard as noted on the lighting fixture schedule.

D. High-Pressure Sodium Lamps:

1. Bulb finish: Clear
2. Any burning position

E. Metal Halide Lamps:

1. Bulb finish: Clear
2. Any burning position

F. LED:

1. Lifespan: 50,000 hour
2. Minimum CRI: 85
3. Minimum Color Temperature: 4000K

G. Furnish a minimum of 2 lamps, or ten percent spare lamps of each type and wattage, whichever is greater.

2.3 FIXTURES

A. Fluorescent Lighting Fixtures:

1. Ballast:
   a. Rapid start, high power factor type
   b. CBM/ETL certified
   c. Sound rating A
   d. Two internal automatic-resetting thermal switch devices for coil and capacitor
2. Internal wiring: AWM, TFN or THHN
3. Channel and end plates: 22 GA steel
4. Steel door frame and socket track: 20 GA steel
5. Channel cover: 24 GA steel
6. Emergency ballast:
   a. Integral rechargeable nickel-cadmium battery, battery charger, and automatic transfer circuitry.
   b. Charging indicator light.
   c. Test Switch.
   d. Provide a minimum of 900 lumen output for 90 minutes upon loss of normal power.
   e. Mounted integral to the fixture.
   f. UL 924 listed.
7. Provide fixtures with emergency ballasts with permanent caution labels warning that the fixture is fed from an un-switched source
   a. Provide emergency ballast also with a similar caution label.

B. HID Lighting Fixtures:

1. Ballasts for high pressure sodium lighting fixtures:
   a. Type: Regulating
   b. Ballast design center variance: Maximum 5 percent from rated lamp wattage.
   c. Lamp wattage regulation spread at the lamp voltage: Maximum 10 percent for +/-10 percent line voltage variation.
   d. Ballast primary current during starting not to exceed normal operating current.
   e. Lamp current crest factor: Maximum 1.8 for +/-10 percent line voltage variation at any lamp voltage, from nominal through life.
   f. Power factor shall not drop below 90 percent for +/-10 percent line voltage variations at any lamp voltage, from nominal through life.
   g. Capacitor variance: Tolerance of +/-6 percent which will not cause more than a +/-8 percent variation in regulation throughout rated lamp life for nominal line voltage.
   h. Capable of operation with an open circuit condition for a maximum of 6 months without significant loss of ballast or starting circuitry life.
2. Ballasts for metal halide/mercury vapor lighting fixtures:
   a. Type: Auto-regulator
   b. Voltage input range: +/-10 percent
   c. Lamp regulation spread: 20 percent maximum

d. Power factor: 90 to 90 percent
e. Input voltage dip (4sec.): 40 to 50 percent
f. Crest factor of lamp current: 1.6 to 2.0

3. Ballasts for exterior HID lamps:
   a. UL approved
   b. High power factor designed for -20 °F temperature starting
4. Fixtures for non-hazardous locations:
   a. Type: Industrial low bay
   b. Ballast housing: Die-cast
   c. Filter: Activated charcoal
   d. Refractor: UV stabilized molded acrylic

C. LED Lighting Fixtures:

1. Heavy duty two piece, die cast aluminum housing.
2. Silicon gasketing for moisture protection
3. Polyester powder finish for impact, corrosion and UV resistance
4. Cast-in aluminum hinges for tool-less lens removal.
5. Thermal and shock resistant clear borosilicate glass refractor.
6. Field replaceable LED light engine and driver.

2.4 EMERGENCY FLUORESCENT POWER UNIT

1. Internal Type: Self-contained, modular, battery-inverter unit, factory mounted within lighting fixture body and compatible with ballast. Comply with UL 924.
   a. Emergency Connection: Operate one fluorescent lamp(s) continuously at an output of 1100 lumens each. Connect unswitched circuit to battery-inverter unit and switched circuit to fixture ballast.
2. Nightlight Connection: Operate one fluorescent lamp continuously.
3. Test Push Button and Indicator Light: Visible and accessible without opening fixture or entering ceiling space.
   a. Push Button: Push-to-test type, in unit housing, simulates loss of normal power and demonstrates unit operability.
   b. Indicator Light: LED indicates normal power on. Normal glow indicates trickle charge; bright glow indicates charging at end of discharge cycle.
4. Battery: Sealed, maintenance-free, nickel-cadmium type.
5. Charger: Fully automatic, solid-state, constant-current type with sealed power transfer relay.
6. Integral Self-Test: Factory-installed electronic device automatically initiates code-required test of unit emergency operation at required intervals. Test failure is annunciated by an integral audible alarm and a flashing red LED.

2.5 EXIT SIGNS

A. General Requirements for Exit Signs: Comply with UL 924; for sign colors, visibility, luminance, and lettering size, comply with authorities having jurisdiction.

B. Internally Lighted Signs:

1. Lamps for AC Operation: Fluorescent, two for each fixture, 20,000 hours of rated lamp life.
2. Lamps for AC Operation: LEDs, 50,000 hours minimum rated lamp life.
3. Self-Powered Exit Signs (Battery Type): Integral automatic charger in a self-contained power pack.
   a. Battery: Sealed, maintenance-free, nickel-cadmium type.
   b. Charger: Fully automatic, solid-state type with sealed transfer relay.
   c. Operation: Relay automatically energizes lamp from battery when circuit voltage drops to 80 percent of nominal voltage or below. When normal voltage is restored, relay disconnects lamps from battery, and battery is automatically recharged and floated on charger.
   d. Test Push Button: Push-to-test type, in unit housing, simulates loss of normal power and demonstrates unit operability.
   e. LED Indicator Light: Indicates normal power on. Normal glow indicates trickle charge; bright glow indicates charging at end of discharge cycle.

2.6 EMERGENCY LIGHTING UNITS

A. General Requirements for Emergency Lighting Units: Self-contained units complying with UL 924.

1. Battery: Sealed, maintenance-free, lead-acid type.
2. Charger: Fully automatic, solid-state type with sealed transfer relay.
3. Operation: Relay automatically turns lamp on when power-supply circuit voltage drops to 80 percent of nominal voltage or below. Lamp automatically disconnects from battery when voltage approaches deep-discharge level. When normal voltage is restored, relay disconnects lamps from battery, and battery is automatically recharged and floated on charger.
4. Test Push Button: Push-to-test type, in unit housing, simulates loss of normal power and demonstrates unit operability.
5. LED Indicator Light: Indicates normal power on. Normal glow indicates trickle charge; bright glow indicates charging at end of discharge cycle.
6. Wire Guard: Heavy-chrome-plated wire guard protects lamp heads or fixtures.
7. Integral Time-Delay Relay: Holds unit on for fixed interval of 15 minutes when power is restored after an outage.

2.7 MISCELLANEOUS ELECTRIC DEVICES

A. PHOTOELECTRIC CONTROL UNITS shall meet the following requirements:

1. Cadmium sulfide photocell
2. Aluminum weatherproof enclosure
3. 30 amp rated contacts
4. 120-volt AC power
5. The Photoelectric control unit shall be Tork Model 2100, or equal.

B. MOTION SENSORS shall meet the following requirements:

1. 110° field of view, 60-foot range

2. Adjustable time setting from 15 seconds to 15 minutes
3. Operating temperature of -20 to + 130 °F.
4. Complete outdoor, weather proof sensor with complete mounting hardware
5. UL listed
6. The motion sensor(s) shall be manufactured by Leviton Model 50500-H or equal.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Lighting fixtures: Set level, plumb, and square with ceilings and walls. Install lamps in each fixture.

B. Comply with NFPA 70 for minimum fixture supports.

C. Install lamps in all luminaires.

D. Replace all failed fluorescent, incandescent, metal halide, mercury vapor, high pressure sodium and LED lamps with new lamps prior to final acceptance by Owner.

E. Surface and flush mounted fixtures shall be solidly connected to a junction box. Suspended fixtures shall be hung utilizing pendant mounting or stainless steel chains and hooks. Each suspended fixture, shall be electrically connected by a length of Type SO flexible cord. 3 conductor No. 14 AWG, minimum, with a twist-lock receptacle mounted in an individual junction box. Plugs and receptacles shall be as manufactured by Hubbell, General Electric Company, or equal.

F. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

G. Install with approved mounting hardware following manufacturer's recommendations.

H. Comply with Section 260529 "Hangers and Supports for Electrical Systems" for channel- and angle-iron supports and nonmetallic channel and angle supports.

1. Do not support fixture from conduit system.
2. Do not support fixture from outlet boxes.

I. Pole mounted fixtures shall be mounted on steel or aluminum poles as indicated on the Plans. All metal poles shall be bonded to the facility ground system. Poles shall have adequate handholes and weatherproof receptacles where indicated.

J. All anchor bolts and nuts shall be stainless steel. Contractor shall paint all steel poles with aluminum paint or other color in accordance with these Contract Documents.

K. Fixture mounting heights and locations indicated on the Plans are approximate and are subject to revision in the field where necessary to avoid conflicts and obstructions.

3.2 ADJUSTING AND CLEANING

A. Wipe all lighting fixture reflectors, lenses, lamps, and trims clean after installation and prior to acceptance of Project by Owner.

3.3 FIELD QUALITY CONTROL

A. Test for Emergency Lighting: Interrupt power supply to demonstrate proper operation. Verify transfer from normal power to battery and retransfer to normal.

END OF SECTION 265000

SECTION 311000 - SITE CLEARING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Clearing and grubbing.
   2. Stripping and stockpiling topsoil.
   3. Temporary erosion- and sedimentation-control measures.

1.2 MATERIAL OWNERSHIP

A. Except materials indicated to be stockpiled or otherwise remain Owner's property, cleared materials shall become Contractor's property and shall be removed from Project site.

1.3 PROJECT CONDITIONS

A. Prior to clearing or excavation operation, Contractor shall meet with the Owner to discuss any issues or potential problems that may arise from such activity.

B. Traffic: Minimize interference with adjoining roads, streets, walks, and other adjacent occupied or used facilities during site-clearing operations.

   1. Do not close or obstruct streets, walks, or other adjacent occupied or used facilities without permission from Owner and authorities having jurisdiction.
   2. Provide alternate routes around closed or obstructed traffic ways if required by Owner or authorities having jurisdiction.

C. Utility Locator Service: Notify utility locator service for area where Project is located before site clearing.

D. Pothole for existing utilities in project areas.

E. Do not commence site clearing operations until temporary erosion- and sedimentation-control and plant-protection measures are in place.

F. The following practices are prohibited outside the limits of construction:

   1. Storage of construction materials, debris, or excavated material.
   2. Parking vehicles or equipment.
   3. Foot traffic.
   4. Erection of sheds or structures.
   5. Impoundment of water.
   6. Excavation or other digging unless otherwise indicated.
   7. Attachment of signs to or wrapping materials around trees or plants unless otherwise indicated.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Satisfactory Soil Material: Requirements for satisfactory soil material are specified in Section 312000 "Earth Moving"

1. Obtain approved borrow soil material off-site when satisfactory soil material is not available on-site.

PART 3 - EXECUTION

3.1 PREPARATION

A. Protect and maintain benchmarks and survey control points from disturbance during construction.

B. Protect existing site improvements to remain from damage during construction.

1. Restore damaged improvements to their original condition, as acceptable to Owner.

3.2 TEMPORARY EROSION AND SEDIMENTATION CONTROL

A. Provide temporary erosion- and sedimentation-control measures to prevent soil erosion and discharge of soil-bearing water runoff or airborne dust to adjacent properties and walkways, according to requirements of authorities having jurisdiction.

B. Verify that flows of water redirected from construction areas or generated by construction activity do not enter or cross protection zones.

C. Inspect, maintain, and repair erosion- and sedimentation-control measures during construction until permanent vegetation has been established.

D. Remove erosion and sedimentation controls and restore and stabilize areas disturbed during removal.

3.3 EXISTING UTILITIES

A. Locate, identify, disconnect, and seal or cap utilities indicated to be removed or abandoned in place.

1. Arrange with Owner/utility companies to shut off indicated utilities.

B. Interrupting Existing Utilities: Do not interrupt utilities serving facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary utility services according to requirements indicated:

1. Notify Owner/Engineer not less than two days in advance of proposed utility interruptions.
2. Do not proceed with utility interruptions without Owner's/Engineer's written permission.

C. Removal of underground utilities is included in earthwork sections and with applicable fire suppression, plumbing, HVAC, electrical, communications, electronic safety and security and utilities sections and Section 024100 "Demolition, Salvage and Reconstruction".

3.4 CLEARING AND GRUBBING

A. Any trash, construction debris, concrete slabs, old pavement, landfill, and buried obstructions such as old foundations shall be traced to the limits and removed.

B. Remove obstructions, trees, shrubs, and other vegetation to permit installation of new construction.

1. Trees to be removed shall be marked and approved by the Owner prior to their removal.

2. Root balls shall be removed completely.

3. Remove obstructions, and debris to a minimum depth of 18 inches below exposed subgrade. Additional removal may be required to accommodate specific pipelines, structures, or other improvements.

C. Fill depressions caused by clearing and grubbing operations with structural fill material unless further excavation or earthwork is indicated.

1. Any excavations resulting from clearing and grubbing should be dish-shaped to the lowest depth of disturbance and backfilled with structural fill.

2. Place fill material in horizontal layers not exceeding a loose depth of 8 inches and compact each layer to a density equal to adjacent original ground.

3.5 TOPSOIL STRIPPING

A. Remove existing site gravel before stripping topsoil.

B. Strip topsoil to depth indicated in section 319000 "Geotechnical Report" in a manner to prevent intermingling with underlying subsoil or other waste materials. Excess trash, debris, concrete and buried obstructions shall be disposed of as indicated in the drawings and at the Engineer's discretion.

C. Organic stripping shall be hauled off site and shall not be used as fill.

D. Stockpile topsoil away from edge of excavations without intermixing with subsoil or other materials. Grade and shape stockpiles to drain surface water. Cover to prevent windblown dust and erosion by water.

3.6 SITE IMPROVEMENTS

A. Remove existing above- and below-grade improvements as indicated and necessary to facilitate new construction.

3.7 DISPOSAL OF SURPLUS AND WASTE MATERIALS

A. Remove surplus soil material, unsuitable topsoil and dispose offsite. Remove obstructions, demolished materials, and waste materials including trash and debris, and legally dispose of them off Owner's property.

B. Separate recyclable materials produced during site clearing from other nonrecyclable materials. Store or stockpile without intermixing with other materials and transport them to recycling facilities. Do not interfere with other Project work.

END OF SECTION

SECTION 311100 – FINISH GRADING AND LANDSCAPING

PART 1 - GENERAL

1.1 WORK INCLUDED

A. Provide all labor, materials, services and equipment indicated on the Drawings and/or herein specified to complete all Finish Grading Work.

B. Finish grading shall consist of the final grading and shaping of all areas, except those areas under pavements, slabs and structures, to conform to lines, elevations and shapes as indicated on the Drawings.

1.2 DEFINITIONS

A. Subgrade: Subgrade shall mean surfaces upon which additional specified materials are to be placed, prepared or constructed.

B. Rough Grading: Rough grading shall mean the act that includes the spreading or placement of specified materials to the tolerances defined as final rough grade.

C. Final Rough Grade: Final rough grade shall mean the establishment of grades to a .15 foot plus or minus tolerance of grades required to accomplish the work described in other sections of the specifications on the drawings (i.e. landscape work, finish grading, concrete work, asphalt work, etc.)

D. Finish Grading: Finish grading shall mean the act that includes the spreading or placement of specified materials to establish the tolerances defined as final finish grade.

E. Final Finish Grade: Final finish grade shall mean the establishment of grades to a plus or minus tolerance of final grades as indicated on drawings. Tolerances are specified in applicable sections of the specifications (i.e. concrete, asphalt, finish grading, etc.).

1.3 RELATED WORK

A. Division One - General Requirements.

1.4 SUBMITTALS

A. Topsoil shall be subject to inspection and approval at the source of supply or upon delivery.

1.5 QUALITY ASSURANCE

A. All spot elevations to be staked for verification and approval by the Engineer.

B. Finish grade tolerance shall be within plus or minus 0.15 foot of final grades indicated on drawings.

C. Finished grades shall conform to shapes, spot elevations and contours, as indicated on drawings, with uniform levels or slopes between finished elevations or between finished elevations and existing elevations.

PART 2 - PRODUCTS

2.1 IMPORTED FILL MATERIALS

A. As required in Section 312000.

PART 3 - EXECUTION

3.1 GENERAL

A. Conduct work in an orderly manner and so as to not create a nuisance. Dirt shall not be permitted to accumulate on streets or sidewalks not to be washed into storm sewers.

B. Finished grades shall be established using materials as specified.

C. Mass Grading – Refer to Section 312000.

D. Finish grade tolerance shall be within plus or minus .15 foot of final grades indicated on drawings.

E. Finished grades shall conform to shapes, spot elevations and contours, as indicated on drawings, with uniform levels or slopes between finished elevations and existing elevations.

F. Finished grades shall be established to provide after settling, adequate drainage in a uniform way so no water pockets or ridges will be created.

3.2 FINISH GRADING

A. Fine grade all areas to a smooth, and uniform surface.

END OF SECTION

SECTION 312000 - EARTH MOVING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Base Course for concrete walks, pavements, and roadway areas.
2. Structural fill for building pads, concrete structures and auxiliary structures.
3. Bedding course for pipe and utility trenches.
4. Drainage course.
5. Controlled Low Strength Material (CLSM) for structural fill applications.
6. Accessories.
7. Clearing and Grubbing.
8. Excavation for rough grading the site.
9. Excavation for structures.
10. Excavation for piping and utility trenches.
11. Installation and compaction requirements.

1.2 RELATED SECTIONS

A. 033000 “Cast-in-Place Concrete” for sheet vapor retarder requirements.

B. 319000 “Geotechnical Report” for additional information regarding existing soils and recommendations.

1.3 DEFINITIONS

A. Backfill: Soil material used to fill an excavation.

1. Initial Backfill: Backfill placed beside and over pipe in a trench, including haunches to support sides of pipe.
2. Final Backfill: Backfill placed over initial backfill to fill a trench.
3. Structural Backfill: Backfill placed below building pads, foundations, concrete structures and other areas where specified.

B. Base Course: Aggregate layer placed between the subbase course and hot-mix asphalt paving.

C. Bedding Course: Aggregate layer placed over the excavated subgrade in a trench before laying pipe.

D. Borrow Soil: Satisfactory soil imported from off-site for use as fill or backfill.

E. Drainage Course: Aggregate layer supporting the slab-on-grade and building slabs that also minimizes upward capillary flow of pore water.

F. Excavation: Removal of material encountered above subgrade elevations and to lines and dimensions indicated.

1. Authorized Additional Excavation: Excavation below subgrade elevations or beyond indicated lines and dimensions as directed by Engineer. Authorized additional excavation and replacement material will be paid for according to Contract provisions for changes in the Work.
2. Unauthorized Excavation: Excavation below subgrade elevations or beyond indicated lines and dimensions without direction by Engineer. Unauthorized excavation, as well as remedial work directed by Engineer, shall be without additional compensation.

G. Fill: Soil materials used to raise existing grades.

H. Structures: Buildings, footings, foundations, retaining walls, slabs, tanks, curbs, mechanical and electrical appurtenances, or other man-made stationary features constructed above or below the ground surface.

I. Subgrade: Uppermost surface of an excavation or the top surface of a fill or backfill immediately below base, drainage fill, drainage course, or topsoil materials.

J. Utilities: On-site underground pipes, conduits, ducts, and cables, as well as underground services within buildings.

1.4 QUALITY ASSURANCE

A. Contractor shall notify the Engineer of excavation plans a minimum of 48 hours in advance. The plan shall include a description of the location and extents of excavation.

1.5 INFORMATIONAL SUBMITTALS

A. Material test reports.

1.6 PROJECT CONDITIONS

A. Utility Locator Service: Notify utility locator service for area where Project is located before beginning earth moving operations.

PART 2 - PRODUCTS

2.1 SOIL MATERIALS

A. General: Provide borrow soil materials when sufficient satisfactory soil materials are not available from excavations.

B. Satisfactory Soils: On-site soils (following clearing and grubbing) are suitable for use as compacted general fill, utility trench and structural backfill. Borrow materials (Imported Fill Materials) shall be similar to onsite soils or non-expansive, granular soil meeting USCS classifications of SM, SP-SM, or SW-SM with a maximum rock size of 3 inches. All imported fill soil sources and material gradations shall be approved by the Engineer prior to the material being hauled to the site.

C. Unsatisfactory Soils: Soil Classification Groups GC, SC, CL, ML, OL, CH, MH, OH, and PT according to ASTM D 2487, or a combination of these groups.

1. Unsatisfactory soils also include satisfactory soils not maintained within 2 percent of optimum moisture content at time of compaction.

2. Review Geotechnical Report included in section 319000 for additional information regarding unsuitable soils present on site.

D. Base Course: Base Course shall conform to CALTRANS Class 2 material requirements (3/4 inch maximum size).

E. Structural Fill: On-site soils or Imported fill material meeting the satisfactory soils requirements. Imported structural fill materials shall be subject to Engineer's approval prior to being hauled to the site.

F. Trench Backfill:
1. On-site soil free of debris, vegetation or other deleterious materials meeting the satisfactory soils requirements.
2. Trench backfill within roadways at a minimum shall conform to the County Standard No.818 – Utility Trench Backfill.

G. Bedding Course:
1. Pipe bedding/envelope material shall be a graded granular material.

Sieve Size	Percentage Passing
3/8-inch	100
No. 4	90-100
No. 50	10-40
No. 100	3-20
No. 200	0-15

2. Clean Concrete Sand (Sand Equivalent SE > 30)

H. Drainage Course:
1. For drainage course under building slabs and slabs on grade use 4-inch thick layer of clean concrete sand (sand equivalent SE>30) with 90-100% passing the #4 sieve.
2. In all other locations use a narrowly graded mixture of washed crushed stone, or crushed gravel; the gradation shall have the following gradation requirements:

Sieve Size	Percentage Passing
1-1/2-inch	100
3/4-inch	90-100
3/8-inch	40-100
No. 4	5-40
No. 8	0-5

2.2 CONTROLLED LOW STRENGTH MATERIAL (CLSM)

A. Where indicated in the drawings and when approved by the Engineer, Controlled Low Strength Material (CLSM) may be used as trench backfill, structural backfill, pipe bedding, or pipe backfill. CLSM shall consist of Portland cement, aggregates, water and fly ash. Chemical admixtures and other mineral admixtures may be used when approved by the Engineer.

B. The actual mix proportions and flow characteristics shall be determined by the producer of the CLSM to meet jobsite conditions and shall be approved by the Engineer. The mixture shall be workable and non-segregating.

C. The minimum compressive strength, unless noted otherwise shall be 1,200 psi.

2.3 ACCESSORIES

A. Detectable Warning Tape: Acid- and alkali-resistant, polyethylene film warning tape manufactured for marking and identifying underground utilities, a minimum of 6 inches wide and 4 mils thick, continuously inscribed with a description of the utility, with metallic core encased in a protective jacket for corrosion protection, detectable by metal detector when tape is buried up to 30 inches deep; colored to comply with local practice or requirements of authorities having jurisdiction.

PART 3 - EXECUTION

3.1 PREPARATION

A. Protect structures, utilities, sidewalks, pavements, and other facilities from damage caused by settlement, lateral movement, undermining, washout, and other hazards created by earth moving operations.

B. Protect and maintain erosion and sedimentation controls during earth moving operations.

C. Protect subgrades and foundation soils from freezing temperatures and frost. Remove temporary protection before placing subsequent materials.

3.2 CLEARING AND GRUBBING

A. All surface improvements, debris and/or vegetation including grass, trees, and weeds on the site should be removed from the construction area. Root balls shall be completely excavated. Organic stripping shall be hauled off from the site and shall not be used as fill. Any trash, construction debris, concrete slabs, old pavement, landfill, and buried obstructions such as old foundations and utility lines exposed should be traced to the limits of the foreign materials and removed. Any excavations resulting from site clearing and grubbing should be dish-shaped to the lowest depth of disturbance and backfilled with structural fill.

3.3 MASS GRADING

A. Prior to placement of any fill material, the surface 12 inches of soil should be removed, and the exposed surface should be uniformly moisture conditioned to a depth of 8 inches by discing and wetting to +/-2% of optimum moisture and re-compacted to at least 90% of ASTM D1557 maximum density. Native soils (following clearing and grubbing), free of organics, rubbish and any deleterious materials may be used for mass grading, placed in 6-inch maximum lifts, uniformly moisture conditioned to a depth of 8 inches by discing and wetting to +/-2% of optimum moisture and re-compacted to at least 90% of ASTM D1557 maximum density.

3.4 EXCAVATION, GENERAL

A. Unclassified Excavation: Excavate to subgrade elevations regardless of the character of surface and subsurface conditions encountered. Unclassified excavated materials may include rock, soil materials, and obstructions. No changes in the Contract Sum or the Contract Time will be authorized for rock excavation or removal of obstructions.

1. If excavated materials intended for fill and backfill include unsatisfactory soil materials and rock, replace with satisfactory soil materials

3.5 EXCAVATION FOR STRUCTURES

A. Excavations shall include the removal of all materials that would interfere with the proper execution of the Work. The removal of said materials shall conform to the lines and grades shown on the plans or ordered by the Engineer. The Contractor shall furnish, place and maintain all supports and shoring that may be required for safety of excavations and protection of adjacent structures and all pumping, ditching or other measures necessary for the removal or exclusion of water, including taking care of storm water, groundwater and wastewater reaching the site of the Work from any source so as to prevent damage to the Work or adjoining property. Excavations shall be sloped or otherwise supported in a safe manner in accordance with applicable State, Federal or local requirements.

1. EXCAVATION FOR BUILDINGS AND CONCRETE STRUCTURES
    a. Building Pad Preparation –
        1) Unless otherwise noted, the following describes the required excavation and subgrade preparation for following structures:
            a) MBR Building
            b) Electrical Building
            c) Solids Handling Building
            d) Solids Holding Tank Blowers Structure
            e) Solids Loading Facility
            f) Auxiliary Structures (, Chemical Storage Concrete Pads, Emergency Generator Concrete Pads and any other structure not specifically noted in other sections).
        2) The existing surface soil within the building pad or concrete structure area(s) should be over-excavated to 24 inches below the lowest foundation grade extending two feet beyond all exterior wall/column lines (including adjacent concreted areas). The exposed sub-grade should be scarified to a

depth of 8 inches, uniformly moisture controlled to +/- 2% of optimum moisture, and re-compacted to at least 90% of ASTM D1557 maximum density.

b. Concrete Structure Preparation –

1) Unless otherwise noted, the following describes the required excavation and subgrade preparation for following structures:

a) Headworks Channel
b) Grit Trap Structure
c) Fine Screens Structure
d) Aeration Basins
e) Equalization Basin
f) Recycled Water Pump Station

2) The existing surface soil within the building pad or concrete structure area(s) should be over-excavated to 24-inches below the lowest foundation grade extending two feet beyond all exterior wall/column lines (including adjacent concreted areas). The exposed sub-grade should be scarified to a depth of 8 inches, uniformly moisture controlled to +/- 2% of optimum moisture by discing and wetting, and re-compacted to at least 90% of ASTM D1557 maximum density.

B. Over-excavations ordered by the Engineer that are not shown or specified and the resulting backfill will be paid for under a separate unit price bid item if such bid item has been established, otherwise payment will be made in accordance with a negotiated price. After the required excavation or over-excavation has been completed the exposed surface shall be scarified to a depth of 8 inches, brought to optimum moisture content and compacted in accordance with the requirements for the specific structure.

C. The Contractor shall keep separate and stockpile from required excavations all topsoil consisting of the top 8-inches of native material. The Contractor shall place and grade this topsoil material as the top 6-inches on areas requiring landscaping, if applicable, to the extent it remains available.

D. The Contractor shall notify the Engineer of the completion of any structural excavation and shall allow the Engineer at least 24-hours review period before the exposed foundation is scarified and compacted or is covered with any structural backfill materials.

E. The Contractor shall remove and dispose of all satisfactory native excess excavated material at a stockpile site identified in the drawings.

F. Excavate to indicated elevations and dimensions within a tolerance of plus or minus 1 inch. If applicable, extend excavations a sufficient distance from structures for placing and removing concrete formwork, for installing services and other construction, and for inspections.

1. Excavations for Footings and Foundations: Do not disturb bottom of excavation. Excavate by hand to final grade including any over excavation requirements. Place and compact structural fill and trim bottoms to required lines and grades to leave solid base to receive other work.

3.6 EXCAVATION FOR WALKS AND PAVEMENTS

A. Excavate surfaces under walks and pavements to indicated lines, cross sections, elevations, and subgrades.

3.7 EXCAVATION FOR UTILITY TRENCHES

A. All trench excavations should conform to CalOSHA requirements for Type C soil. The contractor is solely responsible for the safety of workers entering trenches. Temporary excavations with depths of 4 feet or less may be cut nearly vertical for short duration. Temporary shall be no steeper than 1.5:1 (H:V). Sandy soil slopes should be kept moist, but not saturated, to reduce the potential of raveling or sloughing.

B. Trench excavations deeper than 4 feet will require shoring or slope inclinations in conformance with CalOSHA regulations for Type C soil. Surcharge loads of stockpiled soil or construction materials should be set back from the top of the slope a minimum distance equal to the height of the slope. All permanent slopes should not be steeper the 3:1 to reduce wind and rain erosion. Protected slopes with ground cover may be as steep as 2:1. However, maintenance with motorized equipment may not be possible at his inclination.

C. Unless otherwise shown or ordered, excavation for pipelines and utilities shall be open-cut trenches. The bottom of the trench shall have a minimum width equal to the outside diameter of the pipe plus 24-inches. Trenches for pipelines smaller than 4 inches shall be excavated uniformly to the grade of the bottom of the pipe. Trenches for pipelines inches and larger, unless otherwise ordered by the Engineer, shall be excavated uniformly to the grade 6-inches below the grade of the outside bottom of the pipe. The over-excavation shall be replaced with gravel bedding material as specified herein for the particular type of pipe being installed. The pipe bedding shall be compacted by mechanical means suitable to the Engineer to ninety percent (90%) of relative density. The trench bottom shall be uniformly graded so that each pipe section when first laid will be continually in contact with the bedding along the entire length of the pipe. Where granular backfill under footings encases an underdrain piping system or has a thickness of 18-inches or greater or where shown on the Drawings, a layer of soil stabilization fabric shall be placed under the first horizontal layer of granular backfill. Soil stabilizer fabric shall be Mirafi 500 or equal. The sloping or vertical side slopes shall receive a layer of Mirafi 140 NL or equal.

D. The maximum amount of open trench permitted in any one location shall be the length necessary to accommodate the amount of pipe installed and backfilled in a single day. The Contractor shall make every reasonable effort to backfill all trenches at the end of each day. When this is not possible, barricades with warning lights meeting OSHA requirements shall be provided, set and maintained.

E. All pipeline and utility trench excavations shall be kept reasonably free from excess water during excavation, fine grading, pipe laying, and backfilling operations. Ground water shall be lowered to the extent necessary to keep the trench free from water and the trench bottom stable when the work within the trench is in progress. The Contractor shall provide and maintain at all times during construction ample means and equipment with which to properly and promptly remove and dispose of all water entering the excavation or other parts of the Work whether the water be surface water or underground water. The Contractor shall dispose of the water from the Work site in a suitable manner without damage to adjacent property.

F. When ordered by the Engineer, whether indicated on the Drawings or not, trenches shall be over-excavated beyond the depth shown or specified. Such over-excavation shall be to the depth ordered. The trench shall then be backfilled to the grade required. When the over-excavation ordered by the Engineer is 4-inches or greater below the limits shown, additional payment will be made to the Contractor for that portion of the Work which is located below said 4-inch distance. Said additional payment will be made under separate unit price bid items for over-excavation and bedding if such bid items have been established, otherwise payment will be made in accordance with a negotiated price.

G. The Contractor shall remove and dispose of all excess excavated material off-site.

H. Excavate trenches to indicated gradients, lines, depths, and elevations.

3.8 UNAUTHORIZED EXCAVATION

A. Fill unauthorized excavation under foundations or wall footings with 1,200 psi CLSM.

1. Fill unauthorized excavations under other construction, pipe, or conduit as directed by Engineer.

3.9 STORAGE OF SOIL MATERIALS

A. Stockpile borrow soil materials and excavated satisfactory soil materials without intermixing. Place, grade, and shape stockpiles to drain surface water. Cover to prevent windblown dust.

1. Stockpile soil materials away from edge of excavations. Do not store within drip line of remaining trees.

3.10 PIPE AND UTILITY TRENCH BACKFILL

A. Place backfill on subgrades free of water, mud, frost, snow, or ice.

B. Place and compact bedding course on trench bottoms and where indicated. Shape bedding course to provide continuous support for bells, joints, and barrels of pipes and for joints, fittings, and bodies of conduits.

C. Trenches under Footings: Encase all piping that passes under footings with concrete, as detailed in the drawings. Where the depth from the bottom of the footing to the top of the encasement is less than the required depth of drainage course, the area shall be filled with concrete. Where the depth from the bottom of the footing to the top of the encasement is greater than the required depth of drainage course, the area shall be filled with structural fill and drainage course as required herein.

D. Backfill within roadways – Place in layers not more than 6 inches in thickness, uniformly moisture condition to +/-2% of optimum moisture and mechanically compact to a minimum of 90% of ASTM D1557 maximum dry density except for the 12 top inches of trench backfill which shall be compacted to at least 95%. Trench backfill shall only be placed and compacted after encapsulating the buried pipe with suitable bedding and pipe envelope material.

E. Place and compact initial backfill as required in the Specifications.

1. Backfill material shall not be dropped directly on the pipe or utility conduit.

2. Carefully compact initial backfill under pipe haunches and compact evenly up on both sides and along the full length of piping or conduit to avoid damage or displacement of piping or conduit. Coordinate backfilling with utilities testing.

F. Place and compact final backfill as required in the Specifications to final subgrade elevation.

G. Install warning tape directly above utilities, 12 inches below finished grade, except 6 inches below subgrade under pavements and slabs.

H. Pipe-zone and utility trench backfill material shall be spread and compacted in layers not to exceed 6-inches in thickness. Compaction shall be achieved using mechanical equipment. Flooding, ponding or jetting shall not be used for compaction unless otherwise approved by the Engineer. Pipe zone backfill material shall be manually spread around the pipe so that when compacted the pipe zone backfill will provide uniform bearing and side support. Piping shall be protected from lateral displacement and possible damage resulting from impact or unbalanced loading during backfill operations. Trench zone backfill material shall be uniformly spread and mechanically compacted in layers not to exceed 12-inches in thickness. Moisture content shall be uniformly adjusted by wetting or drying as necessary.

I. Pipe zone including bedding compaction requirements shall be ninety-five percent (95%) of maximum density (ASTM D 1557).

J. Trench zone backfill using required excavated material shall be not less than eighty-five (85%) of maximum density except under paved areas, sidewalks, pipelines, utilities and structures which shall not be less than ninety-five percent (95%) of maximum density.

K. Aggregate base course materials shall be placed and compacted to not less than ninety-five percent (95%) of maximum density.

3.11 SOIL FILL

A. Plow, scarify, bench, or break up sloped surfaces steeper than 1 vertical to 4 horizontal so fill material will bond with existing material.

B. Place and compact fill material in 8-inch maximum layers to required elevations using satisfactory native material or approved imported fill material. Compact to 90% of ASTM D1557 maximum density.

3.12 SOIL MOISTURE CONTROL

A. Uniformly moisten or aerate subgrade and each subsequent fill or backfill soil layer before compaction to moisture content indicated in the Geotechnical report.

1. Do not place backfill or fill soil material on surfaces that are muddy, frozen, or contain frost or ice.

2. Remove and replace, or scarify and air dry, otherwise satisfactory soil material that exceeds optimum moisture content and is too wet to compact to specified dry unit weight.

3.13 COMPACTION OF SOIL BACKFILLS AND FILLS UNDER STRUCUTRES

A. Structural fill used below structures shall be placed in maximum 6-inch lifts, uniformly moisture conditioned +/-2% of optimum moisture and re-compacted to a minimum of 90% of ASTM D1557 maximum density.

B. Backfill and fill soil materials not placed below structures may be placed in layers not more than 8 inches in loose depth for material compacted by heavy compaction equipment, and not more than 4 inches in loose depth for material compacted by hand-operated tampers.

C. Place backfill and fill soil materials evenly on all sides of structures to required elevations, and uniformly along the full length of each structure.

D. Backfill shall not be dropped directly on or against any structure. Backfill shall not be placed around or upon any structure until the concrete has attained the required strength to support the loads imposed. Backfill around water retaining structures shall not be placed until the structures have been tested for leaks and the structures are full of water while the backfill is being placed.

E. Equipment weighing more than 10,000 pounds shall not be used closer to walls than a horizontal distance equal to the depth of the fill at that time. Hand operated power compaction equipment shall be used where use of heavier equipment is impractical or restricted due to weight limitations or may cause damage to the structure.

3.14 GRADING

A. General: Uniformly grade areas to a smooth surface, free of irregular surface changes. Comply with compaction requirements and grade to cross sections, lines, and elevations indicated.

B. Site Rough Grading: Slope grades to direct water away from buildings and to prevent ponding. Finish subgrades to required elevations within the following tolerances:

1. Turf or Unpaved Areas: Plus or minus 1 inch.
2. Walks: Plus or minus 1 inch.
3. Pavements: Plus or minus 1/2 inch.

C. Grading inside Building Lines: Finish subgrade to a tolerance of 1/2 inch when tested with a 10-foot straightedge.

3.15 BASE COURSES UNDER PAVEMENTS AND WALKS

A. Place subbase course and base course on subgrades free of mud, frost, snow, or ice.

B. On prepared subgrade, place base course under pavements and walks as follows:

1. Shape base course to required crown elevations and cross-slope grades.

2. Place base course that exceeds 6 inches in compacted thickness in layers of equal thickness, with no compacted layer more than 6 inches thick or less than 3 inches thick.
3. Compact base course at optimum moisture content to required grades, lines, cross sections, and thickness to not less than 95 percent of maximum dry unit weight according to ASTM D 1557.

3.16 VAPOR BARRIER UNDER BUILDING SLABS

A. Below MBR, Solids Handling and Electrical buildings, a sheet vapor retarder shall be installed and placed on top of properly prepared and compacted structural fill material free of mud, frost, snow or ice. The vapor retarder shall be protected from puncture.
   1. The vapor retarder shall extend a minimum of 12-inches into the footing excavation.
   2. Cover vapor retarder with 4 inches of clean concrete sand (sand equivalent SE>30).

3.17 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage a qualified geotechnical engineering testing agency to perform tests and inspections.

B. Allow testing agency to inspect and test subgrades and each fill or backfill layer. Proceed with subsequent earth moving only after test results for previously completed work comply with requirements.

C. Footing Subgrade: At footing subgrades, at least one test of each soil stratum will be performed to verify design bearing capacities. Subsequent verification and approval of other footing subgrades may be based on a visual comparison of subgrade with tested subgrade when approved by Engineer.

D. When testing agency reports that subgrades, fills, or backfills have not achieved degree of compaction specified, scarify and moisten or aerate, or remove and replace soil materials to depth required; recompact and retest until specified compaction is obtained.

3.18 PROTECTION

A. Protecting Graded Areas: Protect newly graded areas from traffic, freezing, and erosion. Keep free of trash and debris.

B. Repair and reestablish grades to specified tolerances where completed or partially completed surfaces become eroded, rutted, settled, or where they lose compaction due to subsequent construction operations or weather conditions.

C. Where settling occurs before Project correction period elapses, remove finished surfacing, backfill with additional soil material, compact, and reconstruct surfacing.

   1. Restore appearance, quality, and condition of finished surfacing to match adjacent work, and eliminate evidence of restoration to greatest extent possible.

3.19 DISPOSAL OF SURPLUS AND WASTE MATERIALS

A. Remove surplus satisfactory soil and waste materials, including unsatisfactory soil, trash, and debris, and legally dispose of them off Owner's property at the Contractor's expense.

3.20 DEWATERING

A. Prevent surface water and subsurface or ground water from flowing into trenches and excavations and from flooding project site and surrounding area.

1. Do not allow water to accumulate in excavations. Remove water to prevent softening of foundation bottoms, undercutting footings, and soil changes detrimental to stability of subgrades and foundations. Provide and maintain pumps, well point, sumps, suction and discharge lines, and other dewatering system components necessary to convey water away from excavations.

2. Establish and maintain temporary drainage ditches and other diversions outside excavation limits to convey rainwater and water removed from excavations to collecting or runoff areas. Do not use trench excavations as temporary drainage ditches.

END OF SECTION 312000

SECTION 315000 - EXCAVATION SUPPORT AND PROTECTION

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes temporary excavation support and protection systems.

1.2 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.

1.3 INFORMATIONAL SUBMITTALS

A. Contractor Calculations: For excavation support and protection system. Include analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

B. Record Drawings: Identify locations and depths of capped utilities, abandoned-in-place support and protection systems, and other subsurface structural, electrical, or mechanical conditions.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Provide, design, monitor, and maintain excavation support and protection system capable of supporting excavation sidewalls and of resisting earth and hydrostatic pressures and superimposed and construction loads.

1. Design excavation support and protection system, including comprehensive engineering analysis by a qualified professional engineer.

B. All excavations shall be adequately shored, braced, and sheeted to prevent earth movement or settlement. Existing structures, piping, duct bank/conduits, and other improvements that are to remain shall be fully protected from damage.

C. Proper shoring, sloping, sheeting, and bracing is required for all excavation where five feet in depth or more is required. A CALOSHA permit shall be obtained for trenches five feet or great in depth. A copy of this permit shall be supplied to the Owner with an additional copy kept at the job site at all times.

D. Contractor shall submit shoring, underpinning, and earth retention calculations and shop drawings to the Owner and Engineer for review and approval prior to commencing the work that requires said retention. All calculations and drawings shall be prepared under the supervision of and signed and stamped by a civil engineer licensed in California.

E. Contractor shall provide positive protection (mat/sheet coverings) for all excavation slopes to protect slopes from instability and deterioration. This includes slopes on soil piles used for pre-loading and surcharging of areas.

PART 3 - EXECUTION

3.1 GENERAL REQUIREMENTS

A. Contractor shall coordinate all elements of the soil retention system with all surrounding utilities, structures, buildings, pipelines, and other improvements that are to remain and need to be protected. Shoring shall account for surcharge and other loading from adjacent footings and structures that are near excavation and require protection.

B. Prior to excavation or installation activities for elements of soil retaining systems, Contractor shall establish benchmarks around the perimeter of the area to be excavated. These marks shall be surveyed for vertical and horizontal movement at frequent intervals during actual excavation and construction work. Results of these surveys shall be submitted to Owner and Engineer for review.

C. A material testing laboratory (furnished by the Owner) shall review and monitor the excavation and soil retention systems. The Contractor shall provide, install and survey the vertical and horizontal movements of the top of the soil retention system as well as benchmarks placed adjacent to and for the retaining system. Results of these surveys will be reviewed by Owner and Owner’s consultants.

3.2 SOLDIER PILES AND LAGGING

A. Install steel soldier piles before starting excavation. Extend soldier piles below excavation grade level to depths adequate to prevent lateral movement. Space soldier piles at regular intervals not to exceed allowable flexural strength of wood lagging. Accurately align exposed faces of flanges to vary not more than 2 inches from a horizontal line and not more than 1:120 out of vertical alignment.

B. Install wood lagging within flanges of soldier piles as excavation proceeds. Trim excavation as required to install lagging. Fill voids behind lagging with soil, and compact.

3.3 SHEET PILING

A. Before starting excavation, install one-piece sheet piling lengths and tightly interlock vertical edges to form a continuous barrier.

B. Accurately place the piling, using templates and guide frames unless otherwise recommended in writing by the sheet piling manufacturer. Limit vertical offset of adjacent sheet piling to 60 inches. Accurately align exposed faces of sheet piling to vary not more than 2 inches from a horizontal line and not more than 1:120 out of vertical alignment.

C. Cut tops of sheet piling to uniform elevation at top of excavation.

3.4 TIEBACKS

A. Drill, install, grout, and tension tiebacks.

B. Test load-carrying capacity of each tieback and replace and retest deficient tiebacks.

1. Have test loading observed by a qualified professional engineer responsible for design of excavation support and protection system.

C. Maintain tiebacks in place until permanent construction is able to withstand lateral earth and hydrostatic pressures.

3.5 BRACING

A. Bracing: Locate bracing to clear columns, floor framing construction, and other permanent work. If necessary to move brace, install new bracing before removing original brace.

1. Do not place bracing where it will be cast into or included in permanent concrete work unless otherwise approved by Engineer.
2. Install internal bracing if required to prevent spreading or distortion of braced frames.
3. Maintain bracing until structural elements are supported by other bracing or until permanent construction is able to withstand lateral earth and hydrostatic pressures.

3.6 REMOVAL AND REPAIRS

A. Remove excavation support and protection systems when construction has progressed sufficiently to support excavation and earth and hydrostatic pressures. Remove in stages to avoid disturbing underlying soils and rock or damaging structures, pavements, facilities, and utilities.

1. Remove excavation support and protection systems to a minimum depth of 48 inches below overlying construction and abandon remainder.

END OF SECTION 315000

SECTION 321216 - ASPHALT PAVING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Cold milling of existing asphalt pavement.
2. Hot-mix asphalt patching.
3. Hot-mix asphalt paving.
4. Hot-mix asphalt overlay.
5. Asphalt curbs.

B. Related Requirements:

1. Section 312000 "Earth Moving" for subgrade preparation, fill material, unbound-aggregate subbase and base courses, and aggregate pavement shoulders.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

1.3 INFORMATIONAL SUBMITTALS

A. Material Certificates: For each paving material.

1.4 QUALITY ASSURANCE

A. Manufacturer Qualifications: A paving-mix manufacturer registered with and approved by authorities having jurisdiction or the DOT of state in which Project is located.

B. Regulatory Requirements: Comply with materials, workmanship, and other applicable requirements of the local standards where the project is located for asphalt paving work.

1. Measurement and payment provisions and safety program submittals included in standard specifications do not apply to this Section.

PART 2 - PRODUCTS

2.1 DESIGN REQUIREMENTS

A. Asphalt and Aggregate thickness shall be as indicated in the drawings.

2.2 AGGREGATES

A. Aggregate base shall conform to Caltrans Class 2 (maximum ¾”), compacted to a minimum of 95% of maximum dry density (ASTM D1557).

B. Coarse Aggregate: ASTM D 692/D 692M, sound; angular crushed stone, crushed gravel, or cured, crushed blast-furnace slag.

C. Fine Aggregate: ASTM D 1073, sharp-edged natural sand or sand prepared from stone, gravel, cured blast-furnace slag, or combinations thereof.

D. Mineral Filler: ASTM D 242/D 242M, rock or slag dust, hydraulic cement, or other inert material.

2.3 ASPHALT MATERIALS

A. Asphalt Binder: AASHTO M 320.

B. Asphaltic concrete shall be Caltrans, Type B, ¾ inch maximum medium grading.

C. Tack Coat: ASTM D 977 or AASHTO M 140 emulsified asphalt, or ASTM D 2397 or AASHTO M 208 cationic emulsified asphalt, slow setting, diluted in water, of suitable grade and consistency for application.

2.4 MIXES

A. Hot-Mix Asphalt: Dense-graded, hot-laid, hot-mix asphalt plant mixes approved by authorities having jurisdiction and complying with the following requirements:

1. Provide mixes with a history of satisfactory performance in geographical area where Project is located.
2. Base Course: Materials for aggregate base shall be as specified in the Geotechnical Report. Aggregate base shall be provided where shown and to the thickness shown. Imported aggregate bases shall be delivered to the job site as uniform mixtures and each layer shall be spread in one operation. Segregation shall be avoided and the base shall be free of pockets of coarse or fine material. The base material shall be spread and compacted in layers of equal thickness and the maximum compacted thickness of any one layer shall not exceed 6-inches. The relative compaction of each layer of aggregate base shall not be less than ninety-five percent (95%) of maximum density when measured in accordance with ASTM D 1557. The compacted surface of the finished aggregate shall be hard, uniform, and smooth to grade.

PART 3 - EXECUTION

3.1 COLD MILLING

A. Clean existing pavement surface of loose and deleterious material immediately before cold milling. Remove existing asphalt pavement by cold milling to grades and cross sections indicated.

1. Mill to a depth of 3 inches.
2. Patch surface depressions deeper than 1 inch after milling, before wearing course is laid.

3.2 PATCHING

A. Asphalt Pavement: Saw cut perimeter of patch and excavate existing pavement section to sound base. Excavate rectangular or trapezoidal patches, extending 12 inches into perimeter of adjacent sound pavement, unless otherwise indicated. Cut excavation faces vertically. Remove excavated material. Recompact existing unbound-aggregate base course to form new subgrade.

B. Portland Cement Concrete Pavement: Break cracked slabs and roll as required to reseat concrete pieces firmly.

1. Remove disintegrated or badly cracked pavement. Excavate rectangular or trapezoidal patches, extending into perimeter of adjacent sound pavement, unless otherwise indicated. Cut excavation faces vertically. Recompact existing unbound-aggregate base course to form new subgrade.

C. Tack Coat: Before placing patch material, apply tack coat uniformly to vertical asphalt surfaces abutting the patch. Apply at a rate of 0.05 to 0.15 gal./sq. yd..

1. Allow tack coat to cure undisturbed before applying hot-mix asphalt paving.
2. Avoid smearing or staining adjoining surfaces, appurtenances, and surroundings. Remove spillages and clean affected surfaces.

D. Placing Patch Material: Fill excavated pavement areas with hot-mix asphalt base mix for full thickness of patch and, while still hot, compact flush with adjacent surface.

3.3 SURFACE PREPARATION

A. General: Immediately before placing asphalt materials, remove loose and deleterious material from substrate surfaces. Ensure that prepared subgrade is ready to receive paving.

B. Proof-roll subgrade below pavements with heavy pneumatic-tired equipment to identify soft pockets and areas of excess yielding. Do not proof-roll wet or saturated subgrades. Any soft pockets shall be repaired.

C. Place pavements on 12 inches of moisture conditioned (at least 2% over optimum) subgrade (native soil) compacted to a minimum of 95% of the maximum dry density determined by ASTM D1557, or the governing agency requirements.

D. Herbicide Treatment: Apply herbicide according to manufacturer's recommended rates and written application instructions. Apply to dry, prepared subgrade or surface of compacted-aggregate base before applying paving materials.

E. Tack Coat: Apply uniformly to surfaces of existing pavement at a rate of 0.05 to 0.15 gal./sq. yd.

1. Allow tack coat to cure undisturbed before applying hot-mix asphalt paving.
2. Avoid smearing or staining adjoining surfaces, appurtenances, and surroundings. Remove spillages and clean affected surfaces.

3.4 PLACING HOT-MIX ASPHALT

A. Machine place hot-mix asphalt on prepared surface, spread uniformly, and strike off. Place asphalt mix by hand in areas inaccessible to equipment in a manner that prevents segregation of mix. Place each course to required grade, cross section, and thickness when compacted.

1. Spread mix at a minimum temperature of 250 deg F.
2. Regulate paver machine speed to obtain smooth, continuous surface free of pulls and tears in asphalt-paving mat.

B. Asphalt concrete shall not be placed when the atmospheric temperature is below 40 degrees F, or during unsuitable weather as determined by the Engineer.

C. Place paving in consecutive strips not less than 10 feet wide unless infill edge strips of a lesser width are required.

D. Promptly correct surface irregularities in paving course behind paver. Use suitable hand tools to remove excess material forming high spots. Fill depressions with hot-mix asphalt to prevent segregation of mix; use suitable hand tools to smooth surface.

3.5 JOINTS

A. Construct joints to ensure a continuous bond between adjoining paving sections. Construct joints free of depressions, with same texture and smoothness as other sections of hot-mix asphalt course.

1. Clean contact surfaces and apply tack coat to joints.
2. Offset longitudinal joints, in successive courses, a minimum of 6 inches.
3. Offset transverse joints, in successive courses, a minimum of 24 inches.
4. Construct transverse joints at each point where paver ends a day's work and resumes work at a subsequent time. Construct these joints using either "bulkhead" or "papered" method according to AI MS-22, for both "Ending a Lane" and "Resumption of Paving Operations."

3.6 COMPACTION

A. General: Begin compaction as soon as placed hot-mix paving will bear roller weight without excessive displacement. Compact hot-mix paving with hot, hand tampers or with vibratory-plate compactors in areas inaccessible to rollers.

   1. Complete compaction before mix temperature cools to 185 deg F.

B. Breakdown Rolling: Complete breakdown or initial rolling immediately after rolling joints and outside edge. Examine surface immediately after breakdown rolling for indicated crown, grade, and smoothness. Correct laydown and rolling operations to comply with requirements.

C. Intermediate Rolling: Begin intermediate rolling immediately after breakdown rolling while hot-mix asphalt is still hot enough to achieve specified density. Continue rolling until hot-mix asphalt course has been uniformly compacted to the following density:

   1. Compact to a minimum of 95% of the 50 blow Marshall Density (ASTM D1559).

D. Finish Rolling: Finish roll paved surfaces to remove roller marks while hot-mix asphalt is still warm.

E. Edge Shaping: While surface is being compacted and finished, trim edges of pavement to proper alignment. Bevel edges while asphalt is still hot; compact thoroughly.

F. Protection: After final rolling, do not permit vehicular traffic on pavement until it has cooled and hardened.

G. Erect barricades to protect paving from traffic until mixture has cooled enough not to become marked.

3.7 ASPHALT CURBS

A. Construct hot-mix asphalt curbs over compacted pavement surfaces. Apply a light tack coat unless pavement surface is still tacky and free from dust. Spread mix at a minimum temperature of 250 deg F.

   1. Asphalt Mix: Same as pavement surface-course mix.

B. Place hot-mix asphalt to curb cross section indicated or, if not indicated, to local standard shapes, by machine or by hand in wood or metal forms. Tamp hand-placed materials and screed to smooth finish. Remove forms after hot-mix asphalt has cooled.

3.8 INSTALLATION TOLERANCES

A. Pavement Thickness: Compact each course to produce the thickness indicated in Drawings within the following tolerances:

   1. Base Course: Plus or minus 1/2 inch.
   2. Surface Course: Plus 1/4 inch, no minus.

B. Pavement Surface Smoothness: Compact each course to produce a surface smoothness within the following tolerances as determined by using a 10-foot straightedge applied transversely or longitudinally to paved areas:

1. Base Course: 1/4 inch.
2. Surface Course: 1/8 inch.
3. Crowned Surfaces: Test with crowned template centered and at right angle to crown. Maximum allowable variance from template is 1/4 inch.

3.9 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.

B. Replace and compact hot-mix asphalt where core tests were taken.

C. Remove and replace or install additional hot-mix asphalt where test results or measurements indicate that it does not comply with specified requirements.

3.10 WASTE HANDLING

A. General: Handle asphalt-paving waste according to approved waste management plan required in Section 017419 "Construction Waste Management and Disposal."

END OF SECTION 321216

SECTION 323113 - CHAIN LINK FENCES AND GATES

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes:
   1. Fence, framework, fabric, and accessories.
   2. Excavation for post bases and concrete foundations for posts.
   3. Manual gates and related hardware.

B. Description:
   1. All work on the project will take place on the perimeter of the existing site and will include replacing and connecting into existing fencing. This section is solely for chain link fence for fencing specifically indicated as "Chain Link Fencing" in the design drawings. Other fencing types (as indicated in the drawings) must match existing fencing in size, type and materials of construction as detailed in the Civil Details of Volume 4A. Refer to civil grading and site plans in Volume 4A for required locations of chain link and specialty fencing.

1.2 REFERNCES

A. ASTM A36 Standard Specification for Carbon Structural Steel

B. ASTM A121 Standard Specification for Metallic-Coated Carbon Steel Barbed Wire

C. ASTM A 123 Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel products.

D. ASTM A 153 Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel products.

E. ASTM A392 Standard Specification for Zinc-Coated Steel Chain-Link Fabric

F. ASTM A780 Standard Practice for Repair of Damaged and Uncoated Areas of Hot-dip Galvanized Coatings

G. ASTM A817 Standard Specification for Metallic-Coated Steel Wire for Chain Link Fence Fabric and Marcelled Tension Wire

H. ASTM A824 Standard Specification for Metallic-Coated Steel Marcelled Tension Wire for Use With Chain Link

I. ASTM B221 Standard Specification for Aluminum and Aluminum Alloy Bars, Rods, Wire Profiles and Tubes

J. ASTM F552 Standard Terminology Relating to Chain Link Fencing

K. ASTM F567 Standard Practice for Installation of Chain Link Fence

L. ASTM F626 Standard Specification for Fence Fittings

M. ASTM F900 Standard Specification for Industrial and Commercial Swing Gates

N. ASTM F1043 Standard Specification for Strength and Protective Coatings on Steel Industrial Chain Link Fence Framework

O. ASTM F1083 Standard Specification for Pipe, Steel, Hot-Dipped Zinc-Coated (Galvanized) Welded, for Fence Structures

P. ASTM F1184 Standard Specification for Industrial and Commercial Horizontal Slide Gates

Q. ASTM F1910 Standard Specification for Long Barbed Tape Obstacles

R. ASTM F1911 Standard Practice for Installation of Barbed Tape

1.3 PERFORMANCE REQUIRMENTS

A. Delegated Design: Design chain-link fences and gates, including comprehensive engineering analysis by a qualified professional engineer.

B. Structural Performance: Chain-link fence and gate framework shall with stand the effects of gravity and wind loads in accordance with ASCE 7.

1. Minimum post size: Determine according to ASTM F1043 for framework up to 12 feet high, and post sizing not to exceed 10 feet.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product indicated

B. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.

C. Delegated-Design Submittal: For chain-link fences and gate framework provide wind loading analysis data in accordance with ASCE 7 signed and sealed by the qualified professional engineer responsible for their preparation.

1.5 INFORMATIONAL SUBMITTALS

A. Product Certificates: For each type of chain-link fence and gate, from manufacturer.

B. Product Test Reports: For framing strength according to ASTM F 1043.

C. Sample of special warranty.

1.6 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.7 QUALITY ASSURANCE

A. Manufacturer: Company having a minimum 5 years of experience specializing in manufacturing of chain link fence products.

B. Fence Contractor: Contractor having 5 years of experience installing similar projects in accordance with ASTM F567.

1.8 DELIVERY, STORAGE, AND HANDLING

A. Storage and handling: Unload, store, and protect materials such that they are not damaged.

1.9 PROJECT CONDITIONS

A. Field measurements:
   1. Verify actual field distances so that post spacing can be made uniform.
   2. Verify and coordinate gate openings and column distances for entrances.

1.10 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of chain-link fences and gates that fail in materials or workmanship within specified warranty period.

   1. Failures include, but are not limited to, deterioration of metals, metal finishes, and other materials beyond normal weathering.
   2. Warranty Period: Five (5) years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS;

A. Chain link fence and gates: One of the following or equal:
   1. Master-Halco

2.2 CHAIN-LINK FENCE FABRIC

A. General: Provide fabric in one-piece heights measured between top and bottom of outer edge of selvage knuckle or twist. Comply with CLFMI Product Manual and with requirements indicated below:

   1. Fabric Height: As indicated on Drawings.
   2. Steel Wire Fabric: 9-gauge wire.

      a. Mesh Size: 2-1/8 inches.

b. Zinc-Coated Fabric: ASTM A 392, Type II, Class 1, 1.2 oz./sq. ft. with zinc coating applied before weaving.

3. Selvage: Twisted top and knuckled bottom.

4. Supports: Provide the following top and bottom supports:
   a. Top: 1-1/4" Schedule 40 pipe
   b. Bottom: Tension wire

2.3 FENCE FRAMING

A. Posts and Rails: Comply with ASTM F 1043 for framing, including rails, braces, and line; terminal; and corner posts. Provide members with minimum dimensions and wall thickness according to ASTM F 1043 or ASTM F 1083 based on the following:

1. Fence Height: As indicated on Drawings.

2. Heavy Industrial Strength (Minimum steel yield strength 80,000 psi): Material Group IA, round steel pipe, Schedule 40.

   a. Line Post: 2.0 inches in diameter.
   b. End, Corner and Pull Post: 2.5 inches in diameter.

3. Horizontal Framework Members: Top rail complying with ASTM F 1043.
4. Brace Rails: Comply with ASTM F 1043.
5. Metallic Coating for Steel Framing:

   a. Zinc coating 1.8 oz/ft^2 on the inside and outside surface.

2.4 TENSION WIRE

A. Metallic-Coated Steel Wire: 7-gauge, marcelled tension wire complying with ASTM A 817 and ASTM A 824, with the following metallic coating:

1. Type II, zinc coated with minimum coating weight matching chain-link fabric coating weight.

2.5 FITTINGS

A. General: Comply with ASTM F 626.

B. Post caps:
1. Provide post caps that fit snugly over posts to exclude moisture.
   a. Provide dome style caps for terminal posts.
   b. When top rail is specified provide line post loops to secure top rail.

C. Barbed Wire Arms: Galvanized pressed steel, with clips, slots, or other means for attaching strands of barbed wire, and means for attaching to posts, integral with post cap; for each post unless otherwise indicated, and as follows:

1. Provide line posts with arms that accommodate top rail or tension wire.

D. Finish:

1. Metallic Coating for Pressed Steel or Cast Iron: Not less than 1.2 oz. /sq. ft. zinc ASTM F 626.

2.6 FABRIC ACCESSORIES

A. Wire Clips: Minimum 6 gauge hot dip galvanized

B. Tension Bars: ¼ inch by ¾ inch, galvanized

C. Truss Rod Assembly: Galvanized steel minimum 3/8” diameter with pressed steel tightener (galvanized).

D. Steel Bands: 11 gauge, 1 inch wide, hot dip galvanized.

E. Bolts and Nuts: 3/8 inch diameter, galvanized and of commercial quality

2.7 BARBED WIRE

A. Fence:
1. Number of Strands: 3
2. Wires per strand: 2
3. 12.5 gauge galvanized wires with 14 gauge, 4 point galvanized barbs (at no more than 5 inches on center spacing).
4. Coatings: Galvanize in accordance with ASTM A 121, Class 2.

2.8 CHAIN LINK GATES

A. Frames and center supports: minimum 1-7/8-inch outside diameter.

B. Gate accessories:
1. Post top fittings:
   a. Provide post caps that fit snugly over posts to exclude moisture.
   b. Provide dome style caps for terminal posts and loop style caps for line posts.
   c. Post top fittings: Extension arms, 45-degree angle type, capable of receiving three strands of barbed wire.
2. Corner fittings: Heavy pressed steel or malleable castings.
3. Gate tensioning:
   a. Cross tensioning rods: 3/8 inch, galvanized.
   b. Turnbuckles: Heavy duty.
4. Tension rods for 4-foot gates: 3/8 inch, easily adjustable, galvanized.
5. Gate frame corner fittings: Fittings designed for purpose, manufacturer’s standard.

6. Horizontal gate stiffeners: 1-5/8 – inch outside diameter galvanized steel pipe in accordance with ASTM F1043, group IA.
7. Gate hardware:
    a. Catch and locking attachment: combination steel or malleable iron catch and locking attachment of acceptable design.
    b. Stops:
        1) Capable of holding gates open.
    c. Color: Match color of fabric.

2.9 ALUMINUM SLIDE GATE

A. Gate Frame: ASTM F 1183 Type II Class 2 Gate to be made of Aluminum Alloy 6063-T6. All square upright members are 2" sq. weighing 0.94 lb/ft ASTM B221. Complete frame welded to top and bottom frame member 4" x 2" rail.

B. Interior Horizontal Rails: 1-5/8" mounted to posts with galvanized track brackets.

C. Gate post brackets, latch and keepers are galvanized steel.

D. Bracket and roller assemble 2-1/2" X 6" rubber rollers.

E. Gate posts are 4" OD minimum.

F. Latching/locking system to allow for closure of two adjacent gates.

2.10 GROUT AND ANCHORING CEMENT

A. Nonshrink, Nonmetallic Grout: Factory-packaged, nonstaining, noncorrosive, nongaseous grout complying with ASTM C 1107. Provide grout, recommended in writing by manufacturer, for exterior applications.

B. Erosion-Resistant Anchoring Cement: Factory-packaged, nonshrink, nonstaining, hydraulic-controlled expansion cement formulation for mixing with potable water at Project site to create pourable anchoring, patching, and grouting compound. Provide formulation that is resistant to erosion from water exposure without needing protection by a sealer or waterproof coating and that is recommended in writing by manufacturer, for exterior applications.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Examine areas and conditions, with Installer present, for compliance with requirements for a verified survey of property lines and legal boundaries, site clearing, earthwork, pavement work, and other conditions affecting performance of the Work.

    1. Do not begin installation before final grading is completed unless otherwise permitted by Architect.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

C. Stake locations of fence lines, gates, and terminal posts. Do not exceed intervals of 500 feet or line of sight between stakes. Indicate locations of utilities, lawn sprinkler system, underground structures, benchmarks, and property monuments.

D. Install chain-link fencing to comply with ASTM F 567 and more stringent requirements indicated.

E. Post Excavation: Drill or hand-excavate holes for posts to diameters and spacings indicated, in firm, undisturbed soil.

F. Post Setting: Set posts in concrete at indicated spacing into firm, undisturbed soil.

1. Verify that posts are set plumb, aligned, and at correct height and spacing, and hold in position during setting with concrete or mechanical devices.
2. Concrete Fill: Place concrete around posts to dimensions indicated and vibrate or tamp for consolidation. Protect aboveground portion of posts from concrete splatter.

    a. Exposed Concrete: Extend 2 inches above grade; shape and smooth to shed water.
    b. Concealed Concrete: Top 2 inches below grade as indicated on Drawings to allow covering with surface material.

G. Terminal Posts: Locate terminal end, corner, and gate posts per ASTM F 567 and terminal pull posts at changes in horizontal or vertical alignment and as indicated on Drawings. For runs exceeding 500 feet, space pull posts an equal distance between corner or end posts.

H. Line Posts: Space line posts uniformly at 10 feet o.c.

I. Tension Wire: Install according to ASTM F 567, maintaining plumb position and alignment of fencing. Provide horizontal tension wire at the following locations:

1. Extended along top and bottom of fence fabric.
2. As indicated.

J. Chain-Link Fabric: Apply fabric to outside of enclosing framework. Leave 1 inch between finish grade of surface and bottom selvage unless otherwise indicated.

K. Barbed Wire: Install barbed wire uniformly spaced as indicated on Drawings. Pull wire taut, install securely to extension arms, and secure to end post or terminal arms.

L. Install gates according to manufacturer's written instructions, level, plumb, and secure for full opening without interference. Attach fabric as for fencing. Attach hardware using tamper-resistant or concealed means. Install ground-set items in concrete for anchorage. Adjust hardware for smooth operation and lubricate where necessary.

M. Adjust gates to operate smoothly, easily, and quietly, free of binding, warp, excessive deflection, distortion, nonalignment, misplacement, disruption, or malfunction, throughout entire operational range. Confirm that latches and locks engage accurately and securely without forcing or binding.

N. Cantilever slide gates: Install cantilever horizontal slide gates and gate posts in accordance with ASTM F567. Cantilever sliding gates shall be plumb in the closed position with minimal ground clearance and slide with an initial force of 40 lbs.

3.2 SITE CLEAN UP

A. Clean up area adjacent to fence line from debris and unused material created by fence installation

END OF SECTION 323113

SECTION 330505 – PIPELINE TESTING

PART 1 - GENERAL

1.1. SUMMARY

A. The Contractor shall perform flushing and testing of all pipelines and appurtenant piping complete, including conveyance of test water from Owner-designated source to point of use and all disposal thereof, all in accordance with the requirements of the Contract Documents.

B. Section includes provisions for following piping testing:

a. Testing of alignment, grade, and deflection;
b. Gravity flow piping testing;
c. Hydrostatic High Head pressure testing;
d. Hydrostatic Low Head pressure testing;
e. Low pressure air testing;
f. High pressure air testing.

1.2. RELATED SECTIONS

A. General Pipes and Fittings. Section 220050

B. Ductile Iron Pipe. Section 400519

C. Plastic Pipe. Section 400531

D. High Density Polyethylene Pipe and Fittings. Section 400533

E. Stainless Steel Piping and Tubing. Section 400523

F. Steel Piping and Fabricated Steel piping. Section 400524

G. Water Piping. Section 221116

H. Sanitary Waste and Vent Piping. Section 221316

I. Hydraulic Structure Testing. Section 331400

1.3. SUBMITTALS

A. Schedule and Notification of tests:

a. Submit a list of scheduled piping tests by noon of working day preceding the date of scheduled tests.
b. Notification of readiness to test: Before testing notify the Engineer or Construction Manager in writing of readiness to test piping.

c. Have personnel, materials, and equipment required for testing in place before submitting notification of readiness.

B. Provide a test report for each piping system tested. Include the following:

a. Date of Test;
b. Description and identification of piping system tested;
c. Results of alignment, grade, and deflection testing;
d. Type of test performed;
e. Test fluid;
f. Test pressure;
g. Type and location of leaks detected;
h. Corrective action taken to repair leaks;
i. Results of re-testing.

C. Submit test report in accordance with Specification Section 13300.

1.4. SEQUENCE

A. Test Piping Systems as follows:

a. Clean piping before pressure or leak tests.
b. Test exposed, non-insulated piping systems upon completion of system (including supports, hangers, anchors, etc.)
c. Test exposed, insulated piping systems upon completion of system but prior to application of insulation.
d. Test concealed interior piping systems prior to concealment and, if system is insulated prior to application of insulation.
e. Test buried piping (insulated and non-insulated) prior to backfilling and, if insulated, prior to application of insulation.
f. Test buried piping before encasing piping in concrete or covering piping with slab, structure, or permanent improvement.

PART 2 - PRODUCTS

2.1. MATERIALS REQUIREMENTS

A. All test equipment, temporary valves, bulkheads or other water control equipment and materials shall be determined and furnished by the Contractor subject to the Engineer's review.

PART 3 - EXECUTION

3.1. GENERAL

A. Contractor shall make all necessary provisions for conveying the water from the Owner-designated source to the points of use.

B. All pipelines shall be tested. All testing operations shall be performed in the presence of the Construction Manager.

C. Provide air supply.

D. Plug pipe outlets with test plugs. Brace each plug securely to prevent blowouts.

E. Add test fluid slowly.

F. Include regulator set to avoid over-pressurizing and damaging piping.

G. Perform pressure testing in accordance with local, state, and federal requirements.

H. Correct leaks or defects at no additional cost to Owner and as approved by the Engineer.

I. Disposal or release of test water from pipelines after testing, shall be acceptable to the Engineer.

3.2. TESTING ALIGNMENT, GRADE, AND DEFLECTION

A. Alignment and grade:

a. Visually inspect the interior of gravity piping with artificial light, reflected light, or laser beam.
b. Consider inspection complete when no broken or collapsed piping, no open or poorly made joints, no grade changes that affect the piping capacity, or no other defects are observed.

B. Deflection test:

a. Pull a mandrel through the clean piping section under test.
b. Perform the test no sooner than 30 days after installation and not later than 60 days after installation or permanent surfacing.
c. Use a full circle, solid cylinder, or a rigid non-adjustable, odd-numbered leg (9 leg minimum) steel cylinder mandrel approved by the Engineer as to design and manufacture. The circular cross section of the mandrel shall have a diameter of at least 95 percent of the specified average inside pipe diameter of the pipe and the minimum length of the circular portion of the mandrel shall be equal to the nominal diameter of the pipe. Obstructions encountered by the mandrel shall be corrected by the Contractor.

3.3. TESTING OF GRAVITY FLOW PIPING

A. Test gravity flow piping indicated with “G” in piping schedule, as follows:

a. Unless specified otherwise, subject gravity flow piping to the following tests:

i. Alignment and grade.
ii. For plastic piping test for deflection.

iii. Visible leaks and pressure with maximum leakage allowance.

b. Inspect piping for visible leaks before backfilling.
c. Provide temporary restraints when needed to prevent movement of piping.
d. Pressure test piping with maximum leakage allowance after backfilling.
e. With the lower end plugged, fill piping slowly with water while allowing air to escape from high points. Keep piping full under the head indicated in the piping schedule for the water at least 24 hours:

i. Examine piping for visible leaks. Correct any visible leaks. Consider examination complete when no visible leaks are observed.
ii. Maintain piping with water, or allow a new water absorption period of 24 hours for the performance of the pressure test with maximum leakage allowance.
iii. After successful completion of the test for visible leaks and after the piping has been restrained and backfilled, subject piping to the test pressure for minimum of 4 hours while accurately measuring the volume of water added to maintain the test pressure:

1. Consider the test completed when leakage is equal or less than the following maximum leakage allowance:

a) For concrete piping with rubber gasket joints: 80 gallons per day per inch of diameter per mile of piping under test.
b) For HDPE Strom Drain Piping use manufacturer recommended leakage rates.
c) Test sanitary waste and vent piping in accordance with section 221316 requirements.
d) For other piping: 80 gallons per day per inch diameter per mile of piping under test.

B. Repair piping systems sections which fail required piping test, by disassembly and re-installation, using new materials to extent required to overcome leakage. Do not use chemicals, stop-leak compounds, mastics, or other temporary repair methods.

C. Test waste, drain and vent systems in accordance with local plumbing code and these specifications. Repair failed sections by disassembly and reinstallation.

3.4. HYDROSTATIC HIGH HEAD TESTING OF PIPELINES

A. Test piping indicated “HH” in the Piping Schedule with the high head pressure test method.

B. General:

a. The test pressure for yard piping shall be as shown or specified on the Piping Schedule measured at the lowest point of the pipeline section being tested. Where not indicated in the Piping Schedule, test piping systems at 150% of the operating pressure indicated, but not less than 25 psi. Observe each test section for leakage at the end of the test period. Test fails if leakage is observed or if there is any pressure drop in the system. All leaks shall be repaired in a manner acceptable to the Engineer.
b. Prior to hydrostatic testing, all pipelines shall be flushed or blown out as appropriate. The Contractor shall be responsible for ascertaining that all test bulkheads are suitably restrained

to resist the thrust of the test pressure without damage to, or movement of, the adjacent pipe. Care shall be taken to see that all air vents are open during filling. Provide temporary equipment for testing, including pump and gages. Test piping system before insulation is installed, and remove control devices before testing. Test each natural section of each piping system independently but do not use piping system valves to isolate sections where test pressure exceeds valve pressure rating. Fill each section with water and pressurize for indicated pressure and time.

C. Testing Procedures:

a. The pipeline shall be filled at a rate which will not cause any surges or exceed the rate at which the air can be released through the air valves at a reasonable velocity and all the air within the pipeline shall be properly purged. After the pipeline or section thereof has been filled it shall be allowed to stand under a slight pressure for at least 24-hours to allow the concrete or mortar lining, as applicable, to absorb what water it will and to allow the escape of air from any air pockets. During this period, bulkheads, valves and connections shall be examined for leaks. If leaks are found, corrective measures satisfactory to the Engineer shall be taken.
b. Use potable water for all potable water lines testing.
c. Test piping for minimum 2 hours for visible leaks and minimum 2 hours for the pressure test with maximum leakage allowance.
d. Raise pressure to the specified test pressure and inspect piping visually for leaks:

i. Correct any visible leaks,

ii. Consider visible leakage testing complete when no visible leaks are observed.

D. Pressure test with maximum leakage allowance:

a. Leakage allowance is zero for all exposed (insulated or non-insulated) piping and all piping systems using flanged, National Pipe Thread threaded and welded joints.
b. Pressure test piping after completion of visible leaks test.
c. Buried piping with mechanical joints or push-on joints, piping systems shall have maximum allowable leakage of

$$L= (NxDxP^{(1/2)})/7,400$$

Where:
L = Leakage, gallons per hour
N = Number of joints under test
D = Nominal diameter of piping, inches
P = Average pressure during test, pounds per square inch
x = multiplication symbol.

E. Pressure test HDPE pipe in accordance with the requirements of section 221050 “High Density Polyethylene Pipe and Fittings”.

F. Pressure test potable water piping in accordance with the requirements of section 221116 “Water Piping”.

G. Pressure test PEX piping systems in accordance with the requirements of section 238316.

H. Repair piping systems sections which fail required piping test, by disassembly and re-installation, using new materials to extent required to overcome leakage. Do not use chemicals, stop-leak compounds, mastics, or other temporary repair methods.

I. Drain and dispose of test water from piping systems as directed by the Construction Manager or Engineer after testing and repair work has been completed.

J. Test all pressure piping in accordance with ANSI B31.

3.5. HYDROSTATIC LOW HEAD TESTING OF PIPELINES

A. Test piping indicated “LH” in the Piping Schedule with the low head pressure test method.

B. General:

a. Test pressures shall be as noted in the pipe schedule.
b. During the performance of the tests, test pressure shall not vary more than plus or minus 2 pounds per square inch gauge with respect to the specified test pressure.
c. Test connections, blowoffs, vents closure pieces, and joints into structures including existing bell rings and other appurtances with the piping.
d. Test piping for minimum 2 hours for visible leaks test and minimum 2 hours for the pressure test with maximum leakage allowance.

C. Visible Leaks Test:

a. Subject piping under test to the specified pressure measured at the lowest end.
b. Fill piping under test slowly with water while venting air:
   i. Use potable water for all potable waterlines.
c. Before pressurizing for the tests, retain water in piping under slight pressure for the water absorption period of minimum 24 hours.
d. Raise pressure to the specified test pressure and inspect piping visually for leaks. Correct any visible leaks. Consider testing complete when no visible leaks are observed.

D. Pressure test with maximum leakage allowance.

a. Pressure test piping after completion of visible leaks test.
b. Accurately measure the makeup water necessary to maintain the pressure in the piping section under test during the pressure test period:
   i. Consider the pressure test to be complete when makeup water added is less than the allowable leakage of 80 gallons per inch of nominal diameter, per mile of piping section under test and no damage to piping and appurtances has occurred.
   ii. Successful completion of the leakage test shall have been achieved when the observed leakage is equal or less than the allowable leakage and no damage to piping and appurtances has occurred.

3.6. LOW PRESSURE AIR TESTING

A. Perform low pressure air testing for gravity sewer and drainage piping systems where indicated “AL” in the Piping Schedule.

B. Test pipes between adjacent manholes. Test time for air pressure to drop 1.0 psi.

a. For pipes 4 in. through 36 in. diameter to comply with Table 1.

b. Pipe over 36 inch diameter shall not be tested by the low pressure air method.

C. Preparation:

a. Isolate pipe section to be tested by plugging each end with air tight plugs. Plug end of branches, laterals and wyes which are not to be included in the test section.
b. Brace plugs to prevent slippage and blowout due to internal pressure.
c. One plug shall have inlet tap or other provision for connecting air supply.
d. Air control equipment shall consist of valves and pressure gauges to control rate at which air flows into test section and gauges to monitor air pressure inside pipe.

D. Testing:
a. If pipe to be tested is submerged in water, determine height of water above spring line of pipe at each end of test section and compute average. For each foot of water above pipe's spring line, increase test pressure by 0.43 psi.
b. Add air slowly until pressure inside pipe is raised to 5.0 psi. greater than average back pressure of water that may be over pipe.
c. After pressure of 5.0 psi is obtained, control supply of air so the internal pressure is maintained between 4.5 and 5.0 psi (above average water back pressure) for minimum of 2 minutes to allow temperature of air to come into equilibrium with temperature of pipe.
d. In no case shall the test pressure exceed 9.0 psi or the maximum pressure allowed by the pipe manufacturer.
e. Determine the rate of air lost by time pressure drop method.
  i. After temperature stabilized for a 2 minute period, disconnect air supply. Allow pressure to decrease to 4.6 psi. At this pressure, start stopwatch to determine time required for pressure to drop 1.0 psi. Time required for loss of 1.0 psi is then compared to Table 1.
  ii. If time is equal to or greater than time indicate din table, test shall be acceptable.
  iii. If time is less than time indicated in table, make appropriate repairs and retest.

Table 1. Low Pressure Air Test Times for 1.0 PSIg Pressure Drop.

Pipe Diameter (in)	Minimum Time for 1.0 PSIg Pressure Drop (min:sec)	Pipe Length for Minimum Time (ft.)	Test Time for Pipe Length (L) in Excess of Minimum (sec.)
4	03:47	597	.380L
6	05:40	398	.854L
8	07:33	298	1.520L
10	09:27	239	2.374L
12	11:20	199	3.418L
15	14:10	159	5.342L
18	17:00	133	7.692L
21	19:50	114	10.470L
24	22:40	99	13.674L
27	25:30	88	17.306L
30	28:20	80	21.366L
33	31:10	72	25.852L
36	34:00	66	30.768L

E. Repair piping systems sections which fail required piping test, by disassembly and re-installation, using new materials to extent required to overcome leakage. Do not use chemicals, stop-leak compounds, mastics, or other temporary repair methods.

3.7. HIGH PRESSURE AIR TESTING

A. Perform high pressure air testing for gravity sewer and drainage piping systems where indicated "AH" in the Piping Schedule.

B. Perform preliminary test at not greater than 25 psi. Examine for leakage at joints with soap solution and visual detection of soap bubbles. Correct visible leaks.

C. Perform final test at the pressure specified. Pressure in the system shall be gradually increased until the test pressure is reached. Test pressure shall be maintained for a minimum of 10 minutes and additional time conduct soap bubble test examination of each joint for leakage.

D. Piping system shall show no evidence of leakage. If leakage is evident, make appropriate repairs and retest.

END OF SECTION 330505

SECTION 331400 – HYDRAULIC STRUCTURES TESTING

PART 1 - GENERAL

1.1 THE REQUIREMENT

A. The Contractor shall perform all cleaning, flushing, testing and appurtenant work, including conveyance of test water from Owner-designated source to point of use, and including all disposal thereof, complete and acceptable, for hydraulic structures and appurtenant piping all in accordance with the requirements of the Contract Documents.

1.2 RELATED WORK SPECIFIED ELSEWHERE

A. Pipeline Testing. Section 330505

B. Cast-In-Place Concrete. Section 033000

PART 2 - PRODUCTS

2.1 MATERIALS REQUIREMENTS

A. Temporary valves, bulkheads or other water control equipment and materials shall be as determined by the Contractor subject to the Engineer's review.

PART 3 - EXECUTION

3.1 GENERAL

A. Prior to testing, all hydraulic structures shall be thoroughly cleaned and all surfaces hosed down with a high pressure hose and nozzle. All water, dirt and foreign material accumulated in this cleaning operation shall be removed from the structure.

B. The Contractor shall conduct leakage testing of concrete structures subject to hydrostatic pressure and all appurtenant piping. All testing operations shall be done in the presence of the Engineer.

C. The Contractor shall notify the Engineer at least 48-hours in advance of any planned testing and shall review with the Engineer the testing procedures.

D. Water from the Owner’s reclaimed water system will be provided for testing. However, the Contractor shall make all necessary provisions for conveying the water from the Owner-designated source to the points of use.

E. If industrial paint finishes or other protective coatings are to be applied to the interior surfaces of the hydraulic structure, such coatings shall be applied after all testing operations have been completed.

F. Disposal of test water from structures, after testing has been completed, shall be acceptable to the Engineer.

3.2 TESTING OF HYDRAULIC STRUCTURES

A. General: Testing shall be performed prior to backfilling, except where otherwise acceptable to the Engineer (See drawings for additional requirements). Testing shall not be performed sooner than 14-days after all portions of structure walls and associated roof systems have been completed. The test shall consist of filling the structure with water to the maximum operating water surface. The rate of filling shall not exceed 48-inches of depth per day.

B. Evaporation Calculations: To accurately measure the amount of evaporation, the following procedure shall be observed:

1. A standard 5 gallon bucket shall be filled just below the top, and the elevation noted. The bucket shall then be placed in the water of the structure being tested once filling of the structure is complete.
2. Upon completion of the hydraulic testing of the structure, the amount of water evaporated from the bucket shall be taken as the evaporation amount in the structure.

C. Leakage Test and Repairs: After the structure has been filled, the leakage test shall be performed as follows: An initial water level reading shall be made. Seven days following the initial reading, a second reading shall be made. The structure shall be considered to have passed the test if water loss during the 7-day period, as computed from the two water level readings, does not exceed 0.2 percent of the total volume of water in the structure, after allowance is made for evaporation loss. If intermediate readings or observed leakage indicate that the allowable leakage will be exceeded, the test may be terminated before the end of the 7-day period and appropriate action taken to correct the problem before commencing a new 7-day test period. If the structure continues to fail the leakage test, the Contractor shall empty the structure and shall examine the interior for evidence of any cracking or other conditions that might be responsible for the leakage. Any cracks shall be "vee'd" and sealed with polyurethane sealant in accordance with Section 033000 entitled, "Cast-In-Place Concrete". Any evidence of leakage shall be repaired. Following these operations, the Contractor shall again test the hydraulic structure. The structure will not be accepted as completed until it has passed the leakage test.

3.3 TESTING OF APPURTENANT PIPING

A. Piping appurtenant to hydraulic structures shall be tested as specified in Section 330505 entitled, "Pipeline Testing".

END OF SECTION 331400

SECTION 334200 – FACILITY STORM DRAINAGE PIPING

PART 1 GENERAL

1.1 SCOPE OF WORK

A. Furnish all labor, materials, equipment and incidentals necessary and install and test reinforced concrete pipe for storm drains complete as shown on the Drawings and as specified herein.

B. All pipe and fittings shall be manufactured for this project and no pipe shall be furnished from stock.

1.2 RELATED WORK

A. Installation and testing of plumbing is included in Division 33.

B. Earthwork is included in Division 31.

1.3 SUBMITTALS

A. Submit, in accordance with Section 013300 Contractor Submittals, shop drawings showing layout and details of reinforcement, joint, method of manufacture and installation of pipe, gasket, specials and fittings, the name of the pipe manufacturer and a schedule of pipe lengths including the length of individual pipes by diameter for the entire job.

B. Submit with the shop drawings documentation that the fine and course aggregates to be used in manufacture of the concrete pipe comply with the requirements of Paragraph 2.01C. Documentation shall be less than 6 months old and shall indicate the source of the aggregates and the date of the analysis.

C. Prior to each shipment of pipe, submit certified test reports that the pipe was manufactured and tested in accordance with the ASTM Standards specified herein.

D. Submit the results of the compressive strength tests to the Engineer.

1.4 REFERENCE STANDARDS

A. American Society for Testing and Materials (ASTM)

1. ASTM C33 - Standard Specification for Concrete Aggregates.

2. ASTM C76 - Standard Specification for Reinforced Concrete Culvert, Storm Drain and Sewer Pipe.

3. ASTM C150 - Standard Specification for Portland Cement.

4. ASTM C361 - Standard Specification for Reinforced Concrete Low-Head Pressure Pipe.

5. ASTM C443 - Standard Specification for Joints for Circular Concrete Sewer and Culvert Pipe, Using Rubber Gaskets.

6. ASTM C497 - Standard Test Methods for Concrete Pipe, Manhole Sections or Tile.

7. ASTM 969 – Standard Practice for Infiltration and Exfiltration Acceptance Testing of Installed Precast Concrete Pipe Sewer Lines.

B. Where reference is made to one of the above standards, the revision in effect at the time of bid opening shall apply.

1.5 QUALITY ASSURANCE

A. The manufacturer shall perform the acceptance tests in accordance with ASTM C76.

B. Reinforced concrete pipe manufactured for this Contract may be inspected at the plant for compliance with this Section by an independent testing laboratory provided by the Owner. The manufacturer's cooperation in these inspections shall be required.

C. Inspection of the pipe will be made by the Engineer or other representatives of the Owner after delivery. The pipe shall be subject to rejection at any time on account of failure to meet any of the requirements specified herein, even though pipes may have been accepted as satisfactory at the place of manufacture. Pipe rejected after delivery shall be marked for identification and shall immediately be removed from the job.

PART 2 PRODUCTS

2.1 REINFORCED CONCRETE PIPE

A. Except as otherwise specified herein, pipe shall conform to ASTM C76, Class V. The pipe interior shall be smooth and even, free from roughness, projections, indentations, offsets, or irregularities of any kind. The concrete mass shall be dense and uniform.

B. Cement shall be non-air-entraining Portland Cement conforming to ASTM C150, Type II. The use of any admixture shall be subject to the specific approval of the Engineer.

C. Fine aggregate shall consist of washed inert sand conforming to the requirements of ASTM C33, except for gradation, with a maximum loss of 8 percent when subjected to 5 cycles of the soundness test using magnesium sulfate. Coarse aggregate shall consist of well-graded crushed stone or washed gravel conforming to the requirements of ASTM C33, except for gradation, with a maximum loss of 8 percent when subjected to 5 cycles of the soundness test using magnesium sulfate. Documentation that the aggregates to be used in the manufacture of reinforced concrete pipe meet these requirements shall be submitted to the Engineer as stated in Paragraph 1.03 above.

D. The 28-day compressive strength of the concrete as indicated by cores cut from the pipe or from representative test cylinders taken from the same batch shall be equal to or greater than the design strength of the concrete. The concrete mass shall be dense and uniform.

The average adsorption shall not exceed the percentages specified in ASTM C76, Section 11.9. Quadrant steel shall not be used. Reinforcement shall be installed in both the bell and the spigot. At least one circumferential reinforcement wire shall be in both the bell and spigot area and reinforcement in the bell and spigot shall be adequate to prevent damage to concrete during shipping, handling and after installation. The pipe shall be subjected to a 3-edge bearing test and hydrostatic testing to 13 psi for 10 minutes in accordance with ASTM C443 to verify strength and water tightness. Both the 3-edge bearing test in accordance with ASTM C497 and the hydrostatic test shall be performed at the rate of one pipe per 800 hundred feet of pipe manufactured. The Owner reserves the right to witness the testing.

E. Pipe may be rejected for any of the following reasons:

1. Exposure of any wires, positioning spacers or chairs used to hold the reinforcement in place, or steel reinforcement in any surface of the pipe, except for the ends of the longitudinals, stirrups or spacers specifically permitted by Section 8.2 of ASTM C76.

2. If cores taken show that the transverse reinforcing steel is found to be in excess of 1/4-in out of specified position after the pipe is molded.

3. Any shattering or flaking of concrete at a crack.

4. Voids, with the exception of minor bug holes, on the interior and exterior surfaces of the pipe exceeding 1/4-in in depth unless properly and soundly pointed with mortar or other approved material.

5. Unauthorized application of any wash coat of cement or grout. Any pipe dressing procedures shall be subject to approval of the Engineer.

6. A deficiency greater than 1/4-in from the specified wall thickness of pipe 30-in or smaller in internal diameter.

7. A hollow spot identified by tapping the internal surface of the pipe which is greater than 30-in in length or wider than 3 times the specified wall thickness. Repair of such defective areas not exceeding these limitations may be made as specified in Paragraph 2.01M.

8. Defects that indicate imperfect molding of concrete; or any surface defect indicating honeycomb or open texture rock pockets greater in size than area equal to a square with a side dimension of 2-1/2 times the wall thickness or deeper than two times the maximum graded aggregate size; or local deficiency of cement resulting in loosely bonded concrete, the area of which is greater than 30-in in length or wider than 3 times the specified wall thickness when the defective concrete is removed. Repair of such defects not exceeding these limits may be made as specified in Paragraph 2.01M.

9. Any of the following:

   a. A crack having a width of 0.005 to 0.01-in throughout a continuous length of 36-in or more.

   b. A crack having a width of 0.0 to 0.03-in or more throughout a continuous length of 1-ft or more.

c. Any crack greater than 0.005-in extending through the wall of the pipe and having a length in excess of the wall thickness.

d. Any crack showing two visible lines of separation for a continuous length of 2-ft or more, or an interrupted length of 3-ft or more anywhere in evidence, both inside and outside.

e. Cracks anywhere greater than 0.03-in in width.

F. The pipe shall be clearly marked as required by ASTM C76 in a manner acceptable to the Engineer. The markings may be at either end of the pipe for the convenience of the manufacturer, but for any one size shall always be at the same end of each pipe length. Pipe shall not be shipped until the compressive strength of the concrete has attained as percent of the design strength and not before 7 days after manufacture and/or repair, whichever is the longer.

G. Pipe shall have a minimum laying length of approximately 8-ft, except for closure and other special pieces as approved by the Engineer. Have available at the site sufficient pipe of various lengths to affect closure at manholes or structures that cannot be located to accommodate standard lengths. Short lengths of pipe made for closure, etc, may be used in the pipeline at the end of construction if properly spaced. The length of the incoming and outgoing concrete pipe at each structure shall not exceed 4-ft, except where the joint is cast flush with the exterior wall of the structure or where otherwise noted on the Drawings. Maximum laying length shall not exceed 16-ft, but the installation of 16-ft lengths will depend upon the ability to handle such lengths of pipe in sheeted trenches, comply with trench width requirements, maintain the integrity of the sheeting and avoid disturbance to adjacent ground. If in the opinion of the Engineer the use of 16-ft lengths is impractical, shorter lengths shall be used.

H. Each length of pipe shall be checked against the length noted on the shop drawings. Pipe more than 1-1/2-in longer than that shown on the shop drawings shall not be used on this project. Variations in length of the same pipe shall not exceed ASTM C76 requirements.

I. The Engineer shall have the right to cut cores from such pieces of the finished pipe as he/she selects for inspection and for such tests as he/she may wish to apply. Holes left by the removal of cores shall be filled in an approved manner by and at the expense of the manufacturer. Core drilling shall be carried out by the pipe manufacturer at his/her expense. The number of cores shall not exceed the requirements of ASTM C76.

J. The pipe will be carefully examined for compliance with the appropriate ASTM standard, as specified herein, and shop drawings by the manufacturer prior to shipment. All pipes shall be inspected for general appearance, dimension, "scratch-strength," blisters, cracks, roughness, soundness, etc. All pipes will be checked for soundness by being tapped and scratched at least once on every 50 sq inch of pipe surface. The surface shall be dense and close-textured. Cores also shall serve as a basis for rejection of pipe, particularly if lamination or poor bond of reinforcement is apparent.

K. The manufacturer shall use measuring devices to assure joint assembly is within tolerances of ASTM C76 and as specified herein. If, during construction, the pipes cannot be satisfactorily joined, the manufacturer shall pre-join the pipe at the plant.

L. Only pipe actually conforming to the requirements of ASTM C76 and these specifications shall be shipped. Approved pipe will be so stamped or stenciled on the inside before it is shipped. All pipe which has been damaged after delivery will be rejected and if such pipe already has been laid in the trench, it shall be removed and replaced, entirely at the Contractor's expense.

M. Pits, blisters, rough spots and other imperfections may be repaired, subject to the approval of the Engineer, after demonstration by the manufacturer that strong and permanent repairs result. Repairs shall be carefully inspected before final approval. Non-shrink cement mortar used for repairs shall have a minimum compressive strength of 6,000 psi at the end of 7 days and 7,000 psi at the end of 28 days, when tested in 3-in cylinders stored in the standard manner. Epoxy mortar may be utilized for repairs subject to the approval of the Engineer.

2.2 JOINTS FOR CONCRETE PIPE

A. Joints shall be bell and spigot type joint conforming to ASTM C361 or C443 with provisions for using a round rubber O-Ring gasket in a recess in the spigot end of the pipe or profile gasket in a single step joint. B. The gaskets shall conform to ASTM C361 or ASTM C443 except as otherwise specified herein.

B. The joint and gaskets shall be designed and manufactured so that the completed joint will withstand an internal water pressure in excess of 13 psi for a period of 10 minutes without showing any leakage by the gasket or displacement of it. The pipe manufacturer shall provide facilities for testing the effectiveness of the joints against leakage and one such test may be required for each 800-ft of pipe for each type of joint manufactured. Such tests shall be made by an internal or external pressure against the joint of at least 13 psi for a period of ten minutes in accordance with ASTM C443. The completed joint, when installed in place in the work, shall be capable of withstanding a groundwater pressure of 13 psi without exceeding the allowable leakage specified for the pipe testing.

C. The pipe manufacturer shall furnish information and be on hand during the installation of the first five joints installed under this Contract.

D. The ends of the pipe shall be made true to form and dimension and the bell shall be made by casting against steel forms. The manufacturer shall inspect all pipe joint surfaces for out-of-roundness and pipe ends for squareness.

PART 3 EXECUTION

3.1 LAYING CONCRETE PIPE

A. Care shall be taken in loading, transporting and unloading to prevent injury to the pipe or fittings and the joint surfaces. Pipe or fittings shall not be dropped. All pipe or fittings shall be examined before laying and no piece shall be installed which is found to be defective.

B. As soon as the excavation is completed to the normal grade of the bottom of the trench, place screened gravel bedding in the trench and firmly bed the pipe in this gravel to conform accurately to the lines and grades indicated on the Drawings. Blocking under the pipe will not be permitted.

C. Prior to the installation of any pipe, review the proposed method of installation with the Engineer. Jacks or come-alongs shall be used to force the pipes home. The use of other methods, including the use of motor driven equipment, shall be reviewed by the Engineer. The Engineer reserves the right to direct the Contractor to revise his operation at any time within this Contract.

D. A depression shall be left in the supporting gravel at the joint to prevent contamination of the rubber gasket. Before the pipe is lowered into the trench, the spigot and bell shall be cleaned and free from dirt. Gasket and bell shall be lubricated by a vegetable lubricant which is not soluble in water, furnished by the pipe manufacturer and harmless to the rubber gasket. The pipe shall be properly aligned in the trench to avoid any possibility of contact with the side of the trench and fouling the gasket. As soon as the spigot is centered in the bell of the previously laid pipe, it shall be engaged by approved methods.

E. After the gasket is compressed, but before the pipe is brought home, each gasket shall be checked for proper position around the full circumference of the joint. Steel inserts shall be used to prevent the pipe from going home until the feeler gauge is used to check the final position of the gasket.

F. As soon as the pipe is in place and before the come-along is released, backfill shall be placed as indicated on the Drawings and compacted for at least one-half the length of pipe. Not until this backfill is placed shall the come-along be released. If any motion at joints can be detected, a greater amount of backfill shall be placed before pressure is released. When pipe laying is not in progress, including lunchtime, the open ends of the pipe shall be closed by a watertight plug or other approved means.

G. For each of the pieces to be supplied and used for saddles, plug the remaining two holes not used for the service with non-shrink cement mortar.

H. Regulate the equipment and construction operations such that the loading of the pipe does not exceed the loads for which the pipe is designed and manufactured. Any pipe damaged during construction operations shall promptly and satisfactorily be repaired or replaced at the Contractor's expense.

END OF SECTION 334200

SECTION 338000 - PRECAST CONCRETE MANHOLES AND VAULTS

PART 1 - GENERAL

1.1 THE REQUIREMENT

A. The Contractor shall provide precast concrete manholes, catch basins, drop inlets, potable water vaults; meter vaults, and other pre-cast concrete structures complete and in place, in accordance with the Contract Documents.

1.2 RELATED SECTIONS

A. Section 033000 – Cast-in-place Concrete

B. Section 312000 – Earth Moving

1.3 SPECIFICATIONS, CODES AND STANDARDS

A. Commercial Standards

ASTM A 48	Gray Iron Castings.
ASTM C 150	Portland Cement.
ASTM C 443	Joints for Circular Concrete Sewer and Culvert Pipe, Using Rubber Gaskets.
ASTM C 478	Precast Reinforced Concrete Manhole Sections
ASTM C 877	Standard Specification for External Sealing Bands for Concrete Pipe, Manholes, and Precast Box Sections.
ASTM C 923	Resilient Connectors Between Reinforced Concrete Manhole Structures, Pipes, and Laterals.
ASTM C 990	Standard Specification for Joints for Concrete Pipe, Manholes, and Precast Box Sections Using Preformed Flexible Joint Sealants.

1.4 CONTRACTOR SUBMITTALS

A. General: Furnish submittals in accordance with Section 013300 - Contractor Submittals.

B. Shop Drawings:

1. Show dimensions, locations, lifting inserts, reinforcement, and joints.
2. Structural design calculations for vaults and boxes shall be stamped and signed by a structural engineer registered in the State of California.

C. Manufacturer’s Certification for Manholes and Vaults: Written certification that the structure complies with the requirements of this Section.

D. Manufacturer’s Test Results: Pull out force for manhole steps.

1.5 QUALITY ASSURANCE

A. Inspection: After installation, the Contractor shall demonstrate that manholes and vaults have been properly installed, level, with water-tight joints, at the correct elevations and orientations, and that the backfilling has been carried out in accordance with the Contract Documents.

B. Any precast concrete which arrives on site with voids, cracked, or damaged, or is cracked or damaged during installation shall be cause for rejection. Contractor shall remove precast section(s) from the project site and replace with new undamaged sections at no additional cost to OWNER.

1.6 DELIVERY, STORAGE AND HANDLING

A. Handle precast units in positions consistent with their shape and design. Lift and support only from the support points indicated on the shop drawings.

B. Embedded Lifting or Handling Devices: Capable of supporting units in positions anticipated during manufacturing, storage, transportation and installation.

C. Block and brace units during storage. Provide lateral bracing which is sufficient to prevent bowing and/or warping and will not inhibit curing of the exposed surfaces.

PART 2 - PRODUCTS

2.1 MANHOLES

A. The Contractor shall provide precast manhole sections and conical sections conforming to ASTM C 478 and the requirements of this Section. Cement used in manufacturing the manholes shall be Type II modified Portland cement in accordance with ASTM C 150.

1. 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. Joints shall be minimized and shall be located as close as possible to the top of the structure to help minimize opportunity for groundwater infiltration.

C. Conical sections shall have an eccentric shape and shall be designed to support cast iron frames and covers under an H-20 loading, unless indicated otherwise.

D. Design Criteria: Manhole walls, transitions, conical sections, and base shall be designed per ASTM C 478 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 acting on an empty manhole.
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. External pressures and uplift forces due to groundwater elevations 2 feet below finish grade.
6. Dead load of manhole sections fully supported by the base and transition.
7. Additional reinforcing steel in walls to transfer stresses at openings.

8. 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.

E. Joints shall have lipped male/female ends which shall provide uniform and continuous interior wall surfaces and shall be watertight. All joints (including joints between adjusting rings and manhole structure, other adjusting rings and frame and cover) shall be sealed with a preformed flexible sealant conforming to ASTM C 990.

F. Raw Sewage, Plant Drain, drain manholes, plant effluent and all vaults shall also have each joint wrapped with an external joint sealant meeting ASTM C 877. Concrete for base and channel formation shall be 4000 psi concrete conforming to Section 033000 –Cast-In-Place Concrete.

G. Barrel section to sewer pipe (Raw sewage, plant drain, drain, and plant effluent) connections shall be sealed with flexible resilient connectors complying with ASTM C923 and appropriate for the pipe material being used. Mechanical devices shall be stainless steel.

H. Where required and specified in drawings, manhole steps shall be comprised of 1/2-inch grade 60 steel reinforcement rod encased in polypropylene copolymer plastic. Steps shall have tread width of 14-inches. Furnish test results demonstrating step capability to resist a pull out force of 2200 pounds.

I. Manhole riser sections shall be greater than 12 inches in height.

J. Manhole Manufacturers, or Equal

1. Jensen Precast
2. OLDCASTLE Precast

2.2 FRAMES AND COVERS

A. Castings: Castings for manhole frames, covers, and grates shall be non-rocking with machined flat bearing surfaces, and shall conform to the requirements of ASTM A 48, Class 30. Unless otherwise indicated, cast iron covers and frames shall be heavy traffic type, 30 inches in diameter. Covers shall have cleated surfaces with pick holes and shall be ventilated in improved areas and have a solid lid design in landscape or native areas.

B. Manhole covers shall be with embossed with lettering saying "Sewer", "Storm Sewer", or “Water”.

C. Unless noted otherwise all frames and covers shall be designed for H-20 traffic loading. Grates and curb inlets in traffic areas shall be designed for H-20 traffic loading.

D. Castings Manufacturers, or Equal

1. 1. D & L Supply
2. Neenah Foundry Co.

2.3 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 C 150. The minimum 28-day concrete compressive strength shall be 4,000 psi. 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 h, plus surcharge of 240 psf in areas of vehicular traffic
Where L = loading in psf
h = depth of fill in feet.

D. Unless noted otherwise design loading shall also take into account the lateral and uplift pressure resulting from a groundwater elevation 2 feet below existing grade.

E. 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. All openings through the precast structure shall be reinforced to transfer loads.

1. Joints shall be sealed watertight. All joints (including joints between adjusting rings and manhole structure, other adjusting rings and frame and cover) shall be sealed with a preformed flexible sealant conforming to ASTM C 990. In addition, all joints shall be wrapped with an external joint sealant meeting ASTM C 877.

F. 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.

G. Covers for access openings shall be provided. Frames for covers shall be fabricated from aluminum, 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.

H. Where penetrations of the pre-cast concrete vaults are required for piping, conduit, or ducts, such penetrations shall be accommodated through pre-cast openings or wall sleeves, as indicated. Storm drain structures may also use thin-wall knock-out sections. All openings for penetrations shall be smooth and free of surface irregularities and without exposed steel reinforcing. With the exception of vaults on pressurized water system, vaults need not be designed to resist thrust from piping passing through the vault.

I. Lifting holes shall be plugged with a precast concrete plug sealed with a non-shrink grout.

J. Vault Manufacturers, or Equal

1. Jensen Precast,
2. OLDCASTLE Precast

2.4 FABRICATION

A. Maintain plant records and quality control program during fabrication of structural precast concrete sections. Make all quality control records available to Engineer upon request.

B. Use molds that are rigid, and constructed of material that will result in uniform finished surfaces.

C. If self-consolidating concrete is not used, thoroughly vibrate concrete to ensure proper consolidation, elimination of cold joints, and to minimize trapped air on at the concrete surface.

D. Fabricate and provide the required lifting devices which are compatible with embedded components.

E. Ensure reinforcing steel, anchors, inserts, plates, angle and other cast-in items are sufficiently embedded, properly secured, and correctly located. Ensure the reinforcing steel is properly supported to prevent movement or shifting during fabrication. Inadequate concrete cover over reinforcing shall be cause for rejection.

F. Cure precast concrete sections under identical conditions to develop specified concrete quality.

PART 3 - EXECUTION

3.1 GENERAL

A. Prior to accepting manholes on site, ensure that manhole meet the requirements of these specifications, are constructed of the correct materials, and are not cracked or damaged in any other way.

B. 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.

C. Buried pre-cast concrete vaults and manholes shall be assembled and placed in excavations on properly compacted soil foundations as indicated. Pre-cast concrete vaults and manholes shall be set to grade, plumb and level, and oriented to provide the required dimensions and clearances from pipes and other structures.

D. Prior to backfilling vaults, pipe and conduit penetrations and other, openings shall be sealed with polyurethane sealant or as indicated in the drawings. 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.

3.2 MANHOLES

A. Connect pipe to manhole with flexible connection (unless noted otherwise), as recommended by connection manufacturer. Provide a pipe joint or additional flexible connection 18 inches from the outside of the manhole. Grout around pipe after installation is complete, unless otherwise indicated. All connections shall be watertight.

B. Place top section, cone section or flat slab on top riser section, with the opening positioned over the steps. Top of cone section or flat slab shall be from 10 to 18 inches below finished grade.

C. Install grade rings as required to adjust top of lid and frame to match finish grade elevation. Maximum height of grade rings shall be 12 inches. Maximum number of grade rings shall be two.

D. In paved areas and as indicated in the plans, concrete collars shall be constructed around manhole covers as indicated. Collars shall be of 4000 psi concrete. Collars shall be constructed after pavement has been placed.

E. Steps shall be cast-in-place or vibrated into green concrete.

F. Steps shall be installed 12-inches on centers vertically, not more than 1/2 inch out of plumb. The top step shall be no more then 12-inches below the manhole cover.

G. After manhole base has been completed, furnish and install temporary pipe plugs to seal all interior pipe opening. Plugs shall remain in place until final review and acceptance of completed pipeline. Plugs shall then be removed and shall be property of Contractor.

H. Manhole interiors shall be coated as indicated in the protective coatings schedule.

3.3 QUALITY CONTROL

A. Manholes shall be tested and accepted per the requirements of Section 331400 – Hydraulic Structures Testing. Precast concrete testing is the responsibility of the Contractor and supplier.

B. Do not install precast concrete units until concrete has attained its design compressive strength.

END OF SECTION

SECTION 400500-PIPING, GENERAL

PART 1 - GENERAL

1.1 SUMMARY

A. The Contractor shall furnish and install all piping systems shown and specified, in accordance with the requirements of the Contract Documents. Each system shall be complete with all necessary fittings, hangers, supports, anchors, seismic restraints, expansion joints, flexible connectors, valves, accessories, heat tracing, insulation, lining and coating, testing, disinfection, excavation, backfill and encasement, to provide a functional installation.

B. The piping shown is intended to define the general layout, configuration, routing, method of support, pipe size, and pipe type. The mechanical drawings are not pipe construction or fabrication drawings. It is the Contractor's responsibility to develop the details necessary to construct all mechanical piping systems, to accommodate the specific equipment provided, and to provide and install all spools, spacers, adapters, connectors, etc., for a complete and functional system.

1.2 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

A. Commercial Standards

ANSI/ASME B1.20.1	Pipe Threads, General Purpose (inch)
ANSI B16.5	Pipe Flanges and Flanged Fittings, Steel Nickel Alloy and other Special Alloys
ANSI/AWWA C207	Steel Pipe Flanges for Water Works Service, Sizes 4 in through 144 in.
ANSI/AWWA C606	Grooved and Shouldered Joints
ANSI/AWS D1.1	Structural Welding Code
ASTM A 307	Specification for Carbon Steel Bolts and Studs, 6,000 psi Tensile
ASTM A 325	Specification for High-Strength Bolts for Structural Steel Joints
ASTM D 792	Test Methods for Specific Gravity and Density of Plastics by Displacement
ASTM D 2000	Classification System for Rubber Products in Automotive Applications

1.3 CONTRACTOR SUBMITTALS

A. Submit complete shop drawings and certificates, test reports, affidavits of compliance, of all piping systems, in accordance with the requirements in Section 013300 –Contractor Submittals, and as indicated in the individual piping sections. The shop drawings shall include all necessary dimensions and details on pipe joints, fittings, fitting specials, valves, appurtenances, design calculations, and material lists. The submittals shall include detailed layout, spool, or fabrication drawings which show all pipe spools, spacers, adapters, connectors, fittings, and pipe supports and seismic restraints necessary to accommodate the equipment and valves provided in a complete and functional system.

B. All expenses incurred in making samples for certification of tests shall be borne by the Contractor at no increased cost to the Owner.

C. Submit as part of the shop drawings a statement from the pipe fabricator certifying that all pipes will be fabricated subject to a recognized Quality Control Program. An outline of the program shall be submitted to the Engineer for review prior to the fabrication of any pipe.

1.4 QUALITY ASSURANCE

A. Inspection: All pipe shall be subject to inspection at the place of manufacture. During the manufacture of the pipe, the Engineer shall be given access to all areas where manufacturing is in progress and shall be permitted to make all inspections necessary to confirm compliance with the Specifications.

B. Tests: Except where otherwise indicated, all materials used in the manufacture of the pipe shall be tested in accordance with the applicable specifications and standards. Welds shall be tested as indicated. Perform all tests at no additional cost to the Owner.

C. Welding Requirements: All welding procedures used to fabricate pipe shall be prequalified under the provisions of ANSI/AWS D1.1. Welding procedures shall be required for, but not necessarily limited to, longitudinal and girth or spiral welds for pipe cylinders, spigot and bell ring attachments, reinforcing plates and ring flange welds, and plates for lug connections.

D. Welder Qualifications: All welding shall be done by skilled welders, welding operators, and tackers who have had adequate experience in the methods and materials to be used. Welders shall be qualified under the provisions of ANSI/AWS D1.1 by an independent local, approved testing agency not more than 6 months prior to commencing Work on the pipeline. Machines and electrodes similar to those used in the Work shall be used in qualification tests. Furnish all material and bear the expense of qualifying welders at no increased cost to the Owner.

1.5 MANUFACTURER'S SERVICE REPRESENTATIVE

A. Where the assistance of a manufacturer's service representative is advisable, in order to obtain perfect pipe joints, supports, or special connections, furnish such assistance at no additional cost to the Owner.

1.6 MATERIAL DELIVERY, STORAGE, AND PROTECTION

A. All piping materials, fittings, valves, and accessories shall be delivered in a clean and undamaged condition and stored off the ground, to provide protection against oxidation caused by ground contact. All defective or damaged materials shall be replaced with new materials.

1.7 CLEANUP

A. After completion of the Work, all remaining pipe cuttings, joining and wrapping materials, and other scattered debris, shall be removed from the site. The entire piping system shall be handed over in a clean and functional condition.

PART 2 - PRODUCTS

2.1 GENERAL

A. All pipes, fittings, and appurtenances shall be furnished in accordance with the requirements of the applicable Sections of Divisions 22, 23, 33, 40 and this Section.

B. Pipe Supports: All pipes shall be adequately supported in accordance with the requirements of Section 400507 – Hangers and Supports for Process Piping, and as indicated.

C. Lining: All requirements pertaining to thickness, applications, and curing of pipe lining, are in accordance with the requirements of the applicable Sections of Division 40 , unless otherwise indicated.

D. Coating: All requirements pertaining to thickness, application, and curing of pipe coating, are in accordance with the requirements of the applicable Sections of Division 40, unless otherwise indicated. Pipes above ground or in structures shall be field-painted in accordance with Section 098000 – Protective Coatings.

E. Pressure Rating: All piping systems shall be designed for the maximum expected pressure as defined in Section 330505 - Pipeline Testing, or as indicated on the piping schedule.

F. Grooved Piping Systems: Piping systems with grooved joints and fittings may be provided, if approved by the Engineer, in lieu of screwed, flanged, welded, or mechanical joint systems for steel and ductile iron yard piping above and below ground. All grooved couplings on buried piping must be bonded. To assure uniform and compatible piping components, all grooved fittings, couplings, and valves shall be from the same manufacturer. The Contractor shall make the coupling manufacturer responsible for the selection of the correct style of coupling and gasket for each individual location.

2.2 PIPE FLANGES

A. Flanges: Where the design pressure is 150 psi or less, flanges shall conform to either ANSI/AWWA C207 Class D or ANSI B16.5 150-pound class. Where the design pressure is greater than 150 psi, up to a maximum of 275 psi, flanges shall conform to either ANSI/AWWA C207 Class E, Class F, or ANSI B16.5 150-pound class. However, AWWA flanges shall not be exposed to test pressures greater than 125 percent of rated capacity. For higher test pressures, the next higher rated AWWA flange or an ANSI-rated flange shall be selected. Where the design pressure is greater than 275 psi up to a maximum of 700 psi, flanges shall conform to ANSI B16.5 300-pound class. Flanges shall have flat faces and shall be attached with bolt holes straddling the vertical axis of the pipe unless otherwise shown. Attachment of the flanges to the pipe shall conform to the applicable requirements of ANSI/AWWA C207. Flanges for miscellaneous small pipes shall be in accordance with the standards specified for these pipes.

B. Blind Flanges: Blind flanges shall be in accordance with ANSI/AWWA C207, or with the standards for miscellaneous small pipes. All blind flanges for pipe sizes 12 inches and over shall be provided with lifting eyes in form of welded or screwed eye bolts.

C. Flange Coating: All 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.

D. Flange Bolts: Contractor shall supply all bolts and nuts in conformance with Section 055000 – Metal Fabrications. Studs and bolts shall extend through the nuts a minimum of 1/4 inch. All-thread studs shall be used on all valve flange connections, where space restrictions preclude the use of regular bolts.

E. Insulating Flanges: Insulated flanges shall have bolt holes 1/4 inch diameter greater than the bolt diameter.

F. Insulating Flange Sets: Insulating flange sets shall be provided by the Contractor where shown. Each insulating flange set shall consist of an insulating gasket, insulating sleeves and washers and a steel washer. Insulating sleeves and washers shall be one piece when flange bolt diameter is 1-1/2 inches or smaller and shall be made of acetal resin. For bolt diameters larger than 1-1/2 inches, insulating sleeves and washers shall be two-piece and shall be made of polyethylene or phenolic. Steel washers shall be in accordance with ASTM A 325. Insulating gaskets shall be full-face.

G. Insulating Flange Manufacturers, or Equal
   1. JM Red Devil, Type E
   2. Maloney Pipeline Products Co., Houston
   3. PSI Products, Inc., Burbank, California.

H. Flange Gaskets: Contractor shall provide flange gaskets for all pipe flanges. Gaskets for flanged joints shall be full-faced, 1/16-inch thick compressed sheets of asbestos-free aramid fiber base, with nitrile binder and nonstick coating, suitable for temperatures to 700 degrees F, a pH of 1 to 11, and pressures to 1,000 psig. Blind flanges shall have gaskets covering the entire inside face of the blind flange and shall be cemented to the blind flange. Ring gaskets shall not be permitted.

I. Flange Gasket Manufacturers, or Equal
   1. John Crane, Style 2160.
   2. Garlock, Style 3000.

2.3 THREADED INSULATING CONNECTIONS

A. General: Threaded insulating bushings, unions, or couplings, as appropriate, shall be used for joining threaded pipes of dissimilar metals and for piping systems where corrosion control and cathodic protection are involved.

B. Materials: Threaded insulating connections shall be of nylon, Teflon, polycarbonate, polyethylene, or other nonconductive materials, and shall have ratings and properties to suit the service and loading conditions.

2.4 MECHANICAL-TYPE COUPLINGS (GROOVED OR BANDED PIPE)

A. Construction: Cast mechanical-type couplings shall be provided where shown. The couplings shall conform to the requirements of ANSI/AWWA C606. Bolts and nuts shall conform to the requirements of Section 055000 – Metal Fabrications. All gaskets for mechanical-type couplings shall be compatible with the piping service and fluid utilized, in accordance with the coupling manufacturer's recommendations. The wall thickness of all grooved piping shall conform with the coupling manufacturer's recommendations to suit the highest expected pressure. To avoid stress on equipment, all equipment connections shall have rigid-grooved couplings, or harness sets in sizes where rigid couplings are not available, unless thrust restraint is provided by other means. The Contractor shall have the coupling Manufacturer's service representative verify the correct choice and application of all couplings and gaskets, and the workmanship, to assure a correct installation.

B. Couplings for Steel Pipe, Manufacturers, or Equal
   1. Victaulic Style 44 with Type D Heavy Duty Grooved Adaptor Ends.

C. Ductile Iron Pipe Couplings, Manufacturers, or Equal
   1. Victaulic Style 31 (flexible or rigid grooving).
   2. Note: Ductile iron pipe couplings shall be furnished with flush seal gaskets.

D. Couplings for PVC Pipe, Manufacturers, or Equal
   1. Victaulic Style 775.
   2. Note: Couplings for PVC pipe shall be furnished with radius cut or standard roll grooved pipe ends. Grooved end couplings shall be used on PVC pipe only for Schedule 80 vent piping at the vaults. Grooved end couplings shall not be used for PVC C905 water pipe.

2.5 SLEEVE-TYPE COUPLINGS

A. Construction: Sleeve-type couplings shall be provided where indicated, in accordance with ANSI/AWWA C219 unless otherwise indicated, and shall be of steel with steel bolts, without pipe stop, and shall be of sizes to fit the pipe and fittings. The middle ring shall be not less than 1/4 inch in thickness and shall be either 5 or 7 inches long for sizes up to and including 30 inches and 10 inches long for sizes greater than 30 inches, for standard steel couplings, and 16 inches long for long-sleeve couplings. The followers shall be single-piece contoured mill section welded and cold-expanded as required for the middle rings. They shall be of sufficient strength to accommodate the number of bolts necessary to obtain adequate gasket pressures without excessive rolling. The shape of the follower shall be of such design as to provide positive confinement of the gasket. Bolts and nuts shall conform to the requirements of Section 055000 – Metal Fabrications. Buried sleeve-type couplings shall be epoxy-coated at the factory.

B. Pipe Preparation: The ends of the pipe, where indicated, shall be prepared for flexible steel couplings. Plain ends for use with couplings shall be smooth and round for a distance of 12 inches from the ends of the pipe, with outside diameter not more than 1/64 inch smaller than the nominal outside diameter of the pipe. The middle ring shall be tested by cold-expanding a minimum of one percent beyond the yield point, to proof-test the weld to the strength of the parent metal. The weld of the middle ring shall be subjected to air test for porosity.

C. Gaskets: Gaskets for sleeve-type couplings shall be rubber-compound material that will not deteriorate from age or exposure to air under normal storage or use conditions. Gaskets for wastewater and sewerage applications shall be Buna "N," grade 60, or equivalent suitable elastomer.
   1. The rubber in the gasket shall meet the following specifications:
      a. Color - Jet Black.
      b. Surface - Nonblooming.
      c. Durometer Hardness - 74 " 5.
      d. Tensile Strength - 1,000 psi Minimum.
      e. Elongation - 175 percent Minimum.

2. The gaskets shall be immune to attack by impurities normally found in water or wastewater. All gaskets shall meet the requirements of ASTM D 2000, AA709Z, meeting Suffix B13 Grade 3, except as noted above. All gaskets shall be compatible with the piping service and fluid utilized.

D. Insulating Couplings: Where insulating couplings are required, both ends of the coupling shall have a wedge-shaped gasket which assembles over a rubber sleeve of an insulating compound in order to obtain insulation of all coupling metal parts from the pipe.

E. Restrained Joints: All sleeve-type couplings on pressure lines shall be harnessed unless thrust restraint is provided by other means. Harnesses shall be in accordance with the requirements of the appropriate reference standard, or as shown.

F. Manufacturers, or Equal
1. Dresser, Style 38.
2. Ford Meter Box Co., Inc., Style FC1 or FC3.
3. Smith-Blair, Style 411.
4. Baker, Series 200

2.6 FLANGED END CONNECTORS

A. Flanged coupling adapters, shall be in accordance with AWWA C219.

B. Dismantling joints for connecting flanged pipe shall be AWWA C219 compliant. Provide studs and nuts to seal gasket separate and independent from tie-bar restraint system.

C. All dismantling joints shall be the restrained type per AWWA M-11. Tie-bar restraint system shall conform to ASTM A193-B7 per AWWA M-11 and be designed to withstand the test pressure shown on the Drawings.

D. All dismantling joints shall use standard flanges in accordance with AWWA C207. The thickness of the dismantling joint flanges shall be equal to or greater than the class of flange that is connected to as required by the test pressure as shown on the drawings. Buried flanges shall be wrapped with petroleum was tape per AWWA C217.

E. Manufacturers, or Equal
1. Smith-Blair, Style 972 or 975
2. Baker, Series DJ

2.7 FLEXIBLE CONNECTORS

A. Flexible connectors shall be installed in all piping connections to engines, blowers, compressors, and other vibrating equipment, and where shown. 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 psi, or reinforced, flanged duck and rubber, as best suited for the application. 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 minimum 150 psi working pressure, unless otherwise shown. The connectors shall be 9 inches long, face-to-face flanges, unless otherwise shown. The final material selection shall be approved by the manufacturer. Submit manufacturer's shop drawings and calculations.

2.8 EXPANSION JOINTS

A. All 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. This may be accomplished with expansion loops, bellow-type expansion joints, or sliding-type expansion joints. Expansion joints shall be of stainless steel, monel, rubber, or other materials, best suited for each individual service. Submit detailed calculations and manufacturer's shop drawings, guaranteeing satisfactory performance of all proposed expansion joints, piping layouts showing all anchors and guides, and information on materials, temperature and pressure ratings.

2.9 PIPE THREADS

A. All pipe threads shall be in accordance with ANSI/ASME B1.20.1.

2.10 AIR AND GAS TRAPS

A. Air and gas pipes shall be sloping to low points, provided with drip legs, shutoff valves, strainers and traps. The traps shall be piped to the nearest drain. Air and gas traps shall be not less than 150-pound iron body float type with stainless steel float. Bracket, lever, and pins shall be of stainless steel. Drain traps shall have threaded connections.

B. Manufacturers, or Equal
   1. Armstrong Machine Works.
   2. Spirax Sarco, Inc.

PART 3 - EXECUTION

3.1 GENERAL

A. All pipes, fittings, and appurtenances shall be installed in accordance with the requirements of the applicable Sections of Divisions 22 and 40. The lining manufacturer shall take full responsibility for the complete, final product and its application. All pipe ends and joints at screwed flanges shall be epoxy-coated, to assure continuous protection.

B. Where core drilling is required for pipes passing through existing concrete, core drilling locations shall be determined by radiograph of concrete construction to avoid damage to embedded raceways and rebars.

C. Flanges shall be installed at least 6-inches from a wall. Fittings shall be installed with sufficient clearance for maintenance and removal and reinstallation.

D. All buried non-metallic piping, 4” and greater, shall have both a marking tape placed 12” above the pipe, and a tracer wire placed on top of the pipe. Tracer wire shall be 12 gauge solid copper wire with a plastic coat to prevent corrosion. The tracer shall be secured to the pipe 10 feet and at all bends. Tracer wire shall not be wrapped around a pipe. Tracer wire installation requires access points at least every 300 feet. At access points the tracer wire is brought up to grade with valve boxes, cleanouts, manholes, vaults, or other covered access devices. Splices in tracer wire should be made with split bolt or compression-type connectors. Wire nuts shall not be used. Testing of tracer wire continuity after installation shall be performed.

END OF SECTION 400500

SECTION 400507 – HANGERS AND SUPPORTS FOR PROCESS PIPING

PART 1 - GENERAL

1.1 THE REQUIREMENT

A. The Contractor shall provide pipe supports, seismic restraints, hangers, guides, and anchors, complete, in accordance with the Contract Documents.

1.2 CONTRACTOR SUBMITTALS

A. General: Submittals shall be in accordance with Section 013300 – Contractor Submittals.

B. Shop Drawings: Shop drawings shall include the following information:
1. Drawings of pipe supports, restraints, hangers, anchors, and guides
2. Calculations for special supports and anchors.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS

A. Code Compliance: Piping systems and pipe connections to equipment shall be properly anchored and supported to prevent undue deflection, vibration, dislocation due to seismic events and line pressures, and stresses on piping, equipment, and structures. Supports and parts thereof shall conform to the requirements of ASME B31.1 – Power Piping, except as supplemented or modified below. Supports for plumbing piping shall be in accordance with the latest edition of the applicable plumbing code or local administration requirements.

B. Structural Members: Wherever possible, pipes shall be supported from structural members. Where it is necessary to frame structural members between existing members, such supplementary members shall be provided at no additional cost to the Owner. All supplementary members shall be in accordance with the requirements of the building code and the American Institute of Steel Construction and shall be acceptable to the Engineer.

C. Pipe Hangers: Pipe hangers shall be capable of supporting the pipe in all conditions of operation, allowing free expansion and contraction of the piping, and preventing excessive stress on equipment. Hangers shall have a means of vertical adjustment after erection. Hangers shall be designed to prevent becoming disengaged by any movement of the supported pipe. Hangers subject to shock, seismic disturbances, or thrust imposed by the actuation of safety valves, shall include hydraulic shock suppressors. Hanger rods shall be subject to tensile loading only.

D. Hangers Subject to Horizontal Movements: At hanger locations where lateral or axial movement is anticipated, suitable linkage shall be provided to permit such movement. Where horizontal 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 the 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: Spring-type pipe hangers shall be provided for piping subject to vibration or vertical expansion and contraction, such as engine exhausts and similar piping. Spring-type hangers shall be sized to the manufacturer's printed recommendations and the loading conditions encountered. 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 at all times the compression of the spring. Supports shall be capable of accommodating at least four times the maximum travel due to thermal expansion.

F. Thermal Expansion: Wherever expansion and contraction of piping is expected, a sufficient number of expansion loops or 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 in directions away from the anchored points. Components shall be structurally suitable to withstand loads imposed.

G. Heat Transmission: Supports, hangers, anchors, and guides shall be so designed and insulated, that excessive heat will not be transmitted to the structure or to other equipment.

H. Riser Supports: Where practical, risers shall be supported on each floor with riser clamps and lugs, independent of the connected horizontal piping.

I. Freestanding Piping: Free-standing pipe connections to equipment such as chemical feeders and pumps shall be firmly attached to steel frames fabricated from angles, channels, or I-beams anchored to the structure. Exterior, free-standing overhead piping shall be supported on fabricated pipe stands consisting of pipe columns anchored to concrete footings, with horizontal, welded steel angles and U-bolts or clamps securing the pipes.

J. Materials of Construction:
   1. General: Pipe support assemblies, including framing, shall be steel construction, galvanized after fabrication, with Type 316 stainless steel hardware, and anchors, unless otherwise indicated.
   2. Submerged Supports: Submerged piping, as well as piping, conduits, and equipment in hydraulic structures within 24 inches of the water level, shall be supported with support, assemblies, including framing, hardware, and anchors, constructed of Type 316 stainless steel, unless otherwise indicated.
   3. Corrosive: Piping in chemical and corrosive areas shall be supported with support assemblies, including framing, hardware, and anchors, constructed of Type 316 stainless steel or FRP, unless otherwise indicated.

K. Point Loads: Any meters, valves, heavy equipment, and other point loads on PVC, FRP, and other plastic pipes, shall be supported on both sides, according to manufacturer's recommendations to avoid undue pipe stresses and failures. To avoid point loads, all supports on PVC, FRP, and other plastic piping shall be equipped with extra wide pipe saddles or galvanized steel shields.

L. Noise Reduction: To reduce 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.

2.2 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. Pipe support spacing shall not exceed the maximum spans in the tables below. 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. Vertical supports shall be provided to prevent the pipe from being overstressed from the combination of all loading effects.

1. Support Spacing for Schedule 40 and Schedule 80 Steel Pipe

Nominal Pipe Diameter (inches)	Maximum Span (feet)
1/2	6
3/4 and 1	8
1 - 1/4 to 2	10
3	12
4	14
6	17
8 and 10	19
12 and 14	23
16 and 18	25
20 and Greater	30

2. Support Spacing for Welded Fabricated Steel Pipe

Maximum Spans for Pipe Supported in Minimum **120 degree** contact saddles (feet)

Nominal Pipe Diameter (inches)	3/16	1/4	5/16	3/8	7/16	1/2	5/8	3/4	7/8	1
24	33	37	41	43	45	47				
26	34	38	41	44	46	48				
28	34	38	41	44	47	49				
30	34	38	42	45	48	49				
32	34	39	42	45	48	50				
34	35	39	42	46	48	50				
36	35	39	43	46	49	51	55			
38	35	39	43	46	49	51	55			
40	35	40	43	47	49	52	56			
42	--	40	43	47	50	52	56			
45	--	40	44	47	50	53	57			
48	--	40	44	47	50	53	58	61		
51	--	41	44	48	51	53	58	62		
54	--	41	44	48	51	54	58	62		
57	--	41	44	48	51	54	59	63		
60	--	41	45	48	52	54	59	63	67	70
63	--	41	45	49	52	55	60	64	67	71

66	--	41	45	49	52	55	60	64	68	71
72	--	41	45	49	52	55	61	65	69	72
78	--	41	45	49	53	56	61	66	69	73
84	--	41	46	50	53	56	62	66	70	74
90	--	41	46	50	53	56	62	67	71	74
96	--	42	46	50	54	57	62	67	71	75

3. For steel pipe sizes not presented in this table, the support spacing shall be designed so that the stress on the pipe does not exceed 5,000 psi. Maximum deflection of pipe shall be limited to 1/360th of the span and shall be calculated by using the formula:

$$L = \sqrt{\frac{7500tD}{32t + D}}$$

Where:
t = Thickness (inches)
D = Diameter (inches)
L = Maximum span (feet)

4. Support Spacing for Ductile-Iron Pipe:

Normal Pipe Diameter (inches)	Maximum Span (feet)
All diameters	Two supports per pipe length or 10 feet (one of the 2 supports located at joint)

5. Support Spacing for Copper Tubing:

Normal Pipe Diameter (inches)	Maximum Span (feet)
1/2 to 1 - 1/2	6
2 to 4	10
6 and greater	12

6. Support Spacing for Schedule 80 PVC Pipe:

Normal Pipe Diameter (inches)	Maximum Span at 100 degrees F (feet)
1/2	4
3/4	4.5
1	5
1 - 1/4	5.5
1 - 1/2	5.75
2	6.25
3	7.5
4	8.25
6	10
8	11
10	12.25
12	13.25

2.3 MANUFACTURED SUPPORTS

A. Stock Parts: Where not specifically indicated, designs which are generally accepted as exemplifying good engineering practice and use stock or production parts, shall be utilized wherever possible. Such parts shall be locally available, new, of best commercial quality, designed and rated for the intended purpose.

B. Manufacturers, or Equal
   1. Grinnell Corp. (Supply Sales Company), Cranston, RI
   2. Power Piping Company, Pittsburgh, PA.

2.4 COATING

A. Galvanizing: 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 - Specifications for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.

B. Other Coatings: Other than stainless steel or non-ferrous supports, all supports shall receive protective coatings in accordance with the requirements of Section 098000 – Protective Coatings.

PART 3 - EXECUTION

3.1 INSTALLATION

A. General: Pipe supports, seismic restraints, hangers, brackets, anchors, guides, and inserts shall be fabricated and installed in accordance with the manufacturer's printed instructions and ASME B31.1 - Power Piping. Concrete inserts for pipe hangers and supports shall be coordinated with the form work.

B. Appearance: Pipe supports and hangers shall be positioned to produce an orderly, neat piping system. Hanger rods shall be vertical, without offsets. Hangers shall be adjusted to line up groups of pipes at the proper grade for drainage and venting, as close to ceilings or roofs as possible, without interference with other work.

3.2 FABRICATION

A. Quality Control: Pipe hangers, supports, and seismic restraints shall be fabricated and installed by experienced welders and fitters, using the best welding procedures available. Fabricated supports shall be neat in appearance without sharp corners, burrs, and edges.

END OF SECTION 400507

SECTION 400519 – DUCTILE IRON PIPE

PART 1 - GENERAL

1.1 THE REQUIREMENT

A. The Contractor shall furnish and install all ductile iron pipe, fittings, transitions, connections and appurtenant work, complete and in accordance with the requirements of the Contract Documents.

1.2 RELATED WORK SPECIFIED ELSEWHERE

A. Section 400500 – Piping, General
B. Section 330505 – Pipeline Testing
C. Section 331400 – Hydraulic Structures Testing

1.3 REFERENCE SPECIFICATIONS, CODES AND STANDARDS

A. Commercial Standards:

ANSI/AWWA C104/A21.4	Cement-mortar lining for Ductile Iron and Gray Iron Pipe and Fittings for Water.
ANSI/AWWA C105/A21.5	Polyethylene Encasement for Gray and Ductile Cast Iron Piping for Water and Other Liquids.
ANSI/AWWA C110/A21.10	Fittings, 3-inch through 48-inch for Water and Other Liquids, Gray Iron and Ductile Iron.
ANSI/AWWA C111/A21.11	Rubber Gasket Joints for Ductile Iron and Gray Iron Pressure Pipe and Fittings.
ANSI/AWWA C115/A21.15	Flanged Ductile Iron and Gray Iron Pipe with Threaded Flanges.
ANSI/AWWA C150/A21.50	Thickness Design of Ductile Iron Pipe.
ANSI/AWWA C153/A21.53	Mechanical Joints (MJ), Push-on joints.
ANSI/AWWA C151/A21.51	Ductile Iron Pipe, Centrifugally Cast, in Metal Molds or Sand Lined Molds for Water and Other Liquids.
ANSI/AWWA C209	Cold Applied Coatings for the Exterior of Special Sections, Connections and Fittings for Steel Water Pipelines.
ANSI/AWWA C214	Tape Coating Systems for the Exterior of Steel Water Pipelines.
ANSI/AWWA C600	Water Mains and Appurtenances, Installation of Ductile Iron.
ANSI/ASTM D 1248	Polyethylene Lining Material for Ductile Iron Pipe and Fittings.
ASTM C 150	Specification for Portland Cement.
ASTM A 746	Installation of Ductile Iron Pipe for Gravity Sewers.

1.4 CONTRACTOR SUBMITTALS

A. The Contractor shall furnish a certified affidavit of compliance for all pipe and other products or materials furnished under this Section of the Specifications and as specified in the referenced standards. Certification shall include physical and chemical properties of pipe materials and hydrostatic test reports.

B. All expenses incurred in sampling and testing for certifications shall be borne by the Contractor.

1.5 QUALITY ASSURANCE

A. Ductile iron pipe shall be manufactured with the material, have the dimensions, be within the tolerances and meet the testing requirements set forth in ASTM A746 and ANSI A21.51. Ductile iron pipe shall be manufactured in nominal 18-foot or 20-foot laying lengths and shall have the lining called for in the Contract Documents.

B. All 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.

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 at no additional cost to the Owner.

PART 2 - PRODUCTS

2.1 GENERAL

A. Mortar lined ductile iron pipe shall conform to ANSI/AWWA C151, C104, C105, C214 and D1248, subject to the following supplemental requirements. The pipe shall be of the diameter shown, shall be furnished complete with rubber gaskets as indicated in the Contract Documents and all specials and fittings shall be provided as required under the Contract Documents.

B. The pipe shall be handled by use of wide slings, padded cradles or other devices acceptable to the Engineer, designed and constructed to prevent damage to the pipe lining and/or coating. The use of chains, hooks or other equipment which might injure the pipe lining and coating will not be permitted. Stockpiled pipe shall be safely and properly supported to prevent accidental rolling. The Contractor shall be fully liable for the cost of replacement or repair of pipe which is damaged.

C. Maximum pipe laying lengths shall be 20-foot with shorter lengths provided as required by the Drawings.

D. The pipe shall have a smooth dense interior surface and shall be free from fractures, defects and roughness.

2.2 MATERIALS

A. Ductile iron pipe materials shall conform to the requirements of ANSI/AWWA C151/A21.51.

B. Fittings for ductile iron pipe shall conform to the requirements of ANSI/AWWA C110/A21.10 or AWWA C153 for diameters 3-inch through 48-inch. Ductile iron fittings larger than 48-inch shall conform to the above referenced standard with the necessary modifications for the larger size.

C. Cement for mortar lining shall conform to the requirements of ANSI/AWWA C104/A21.4; provided, that cement for mortar lining shall be Type II or V. A fly ash or pozzolan shall not be used as a cement replacement.

D. Glass lined ductile iron pipe and fittings shall be lined with a vitreous material which is hard, smooth, continuous and formulated to prevent the adherence of grease in sludge and scum lines, and to resist the adherence of crystalline metal salt deposits (struvite and vivionite) to sludge and centrate lines in sewage and wastewater treatment plants. It shall be applied to properly prepared pipe and fittings using accepted industry standards, and shall be tested per applicable ASTM, NACE and SSPC standards.

E. Material for the polyethylene encasement shall conform to the requirements of ANSI/AWWA C105/A21.5.

F. All elastomer gaskets used for ductile iron pipe shall be of neoprene or SBR elastomer material with a 1/8" thickness. For high temperature service (process air) gaskets shall be Viton. For high temperature water service gaskets shall be EPDM.

G. All bolts, nuts, and washers, which are buried, submerged or below the top of the wall inside any hydraulic structure used in the assembly of ductile iron pipe and fittings shall be of Type 316 Stainless Steel.

2.3 DESIGN OF PIPE

A. Ductile iron pipe shall be designed in accordance with the requirements of ANSI/AWWA C150/A21.50, as applicable and as modified in this Section. The pipe furnished shall be either mortar-lined or glass-lined as called out in the Contract Documents.

B. The pipe shall be designed, manufactured, tested, inspected and marked according to applicable requirements previously stated and except as hereinafter modified, shall conform to ANSI/AWWA C151.

C. The pipe and fittings shall be of the diameter shown and shall be of pressure Class 350 for pipe sizes twelve inches and below, pressure Class 250 for pipe fourteen inches to twenty inches, pressure class 200 for twenty-four-inch pipe and pressure class 150 for thirty inch and above, except that where mechanical couplings are used and the pipe is grooved, the ductile iron pipe shall be of special thickness Class 53.

D. Ductile iron pipe and fittings shall be furnished with mechanical joints, push-on joints, flanged joints and restrained joints as required.

1. All Mechanical and push-on joints may conform to ANSI/AWWA C153/A21.53 or C110/A21.10.
2. Flanged joints shall conform to ANSI/AWWA C115/A21.15.

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.

2.4 CEMENT-MORTAR LINING

A. Except as otherwise provided herein, interior surfaces of ductile iron pipe, fittings and specials to be furnished with cement-mortar lining shall be cleaned and lined in the shop with cement-mortar lining applied centrifugally in conformity with ANSI/AWWA C104. If lining is damaged or found faulty at delivery site, the damaged or unsatisfactory portions shall be replaced with lining conforming to these Specifications.

B. The minimum lining thickness shall be as follows:

Nominal Pipe Diameter (inches)	Minimum Lining Thickness (inches)
3-12	1/8
14-24	3/16
30-54	1/4

C. For all pipe and fittings with plant-applied cement mortar linings, the Contractor shall provide a polyethylene or other suitable bulkhead on the ends of the pipe and on all special openings. All bulkheads shall be substantial enough to remain intact during shipping and storage until the pipe is installed.

2.5 GLASS LINING

A. The lining material shall consist of vitreous and inorganic material applied to the internal surfaces that have been prepared by blasting. The lining shall be applied in a minimum of two (2) coats, separately applied and separately fired. The items shall be exposed to a maturing temperature of approximately 1400 degrees F., at which point the vitreous and inorganic materials melt and fuse to the base metal, forming an integral molecular bond with the base metal surface. Subsequent coatings will be processed in a similar manner, forcing an integral molecular bond with the base coat. The entire finished coating shall be a minimum of 10 mils (.010”) as tested with a micro test or other acceptable dry film thickness gauge. The finished lining shall be able to withstand a strain of 0.001 inch/inch (the yield point of the base metal) without damage to the glass. The lining shall be of a light, bright color to allow visual detection of defects more easily prior to electronic holiday detection testing.

B. The lining shall have a hardness of 5-6 on the MOHS scale, and a density of 2.5-3.0 grams per cubic centimeter as measured by ASTM D-792. The glass lining shall be capable of withstanding an instantaneous thermal shock of 350 degrees F. differential without crazing, blistering or spalling. It shall be resistant to corrosion of between PH-3 and PH-10 at 125 degrees F. There shall be no visible loss of surface gloss to the lining after immersing a production sample in an 8% sulfuric acid solution at 148 degrees F. for a period of 10 minutes. When tested according to ASTM C-283, it shall show a weight loss of not more than 3 milligrams per square inch.

C. Per the recommended industry standards under ASTM D-5162-01, NACE RP 0188-99, and SSPC Coating Manual, Volume 1, Section XIV, the glass lining shall be tested by "low voltage, wet sponge, non-destructive holiday detection unit", with only isolated voids permitted due to casting anomalies. Documentation shall be furnished with each shipment of material listing the test results by identifying "mark" or "tag" numbers.

D. The finished glass lined pipe shall not deviate more than 0.0125 inch per foot of length from a centerline perpendicular to the square pipe end or flange face.

E. The applicator shall have a minimum of 5 years of successful experience in the application of high temperature glass and porcelain coatings for the wastewater and sewage treatment industry. All glass lining of pipe and fittings should be from one manufacturer.

F. All handling and/or lifting of glass lined pipe and fittings must be done on the exterior only. Avoid lifting internally with hooks, forks or chains at any time.

2.5 EXTERIOR COATING OF PIPE

A. The exterior surfaces of ductile iron 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 098000 entitled, "Protective Coating." This exposed piping shall not be coated with the bituminous coating by the manufacturer prior to delivery.

B. Buried ductile iron pipe shall be pipe shall be epoxy-coated according to requirements of Section 098000 "Protective Coatings".

C. Submerged ductile iron pipe shall be epoxy-coated according to requirements of Section 098000 "Protective Coatings".

2.5 RESTRAINED JOINTS

A. Restrained joints shall conform to either ANSI/AWWA C111/A21.11 or ANSI/AWWA C153/A21.53.

B. Restraint devices for pipe sizes 3" – 48" shall consist of multiple gripping wedges incorporated into a follower gland meeting the applicable requirements of ANSI/AWWA C110/A21.10. The devices shall have a working pressure rating of 350 psi for 3"-16" and 250 psi for 18"-48". Ratings are for water pressure and must include a minimum safety factor of 2 to 1 in all sizes.

C. Gland body, wedges and wedge actuating components shall be cast from grade 65-45-12 ductile iron material in accordance with ASTM A536. For applications requiring restraint 30" and greater, an alternate grade of iron meeting the material requirements of ASTM A536 is acceptable, providing the device meets all end product performance requirements. Ductile iron gripping wedges shall be heat treated within a range of 370 to 470 BHN.

D. Three (3) test bars shall be incrementally poured per production shift as per UL specifications and ASTM A536. Testing for tensile, yield and elongation shall be done in accordance with ASTM E8. Chemical and nodularity tests shall be performed as recommended by the Ductile Iron Society, on a per ladle basis.

E. Mechanical joint restraint for ductile iron pipe shall be produced by EBAA Iron, Inc and shall be:

a. Megalug Series 1100 for Fittings
b. Megalug Series 1700 for Joints
c. Megalug Series 3800 for Couplings

F. Finish shall be Megabond, or equal.

PART 3 - EXECUTION

3.1 INSTALLATION OF PIPE

A. All pipe, fittings, etc. shall be carefully handled and protected against damage, impact shocks and free fall. All pipe handling equipment shall be acceptable to the Engineer. Pipe shall not be placed directly on rough ground but shall be supported in a manner which will protect the pipe against injury whenever stored at the trench site in accordance with Paragraph 2.1B, herein. All pipe damaged prior to Substantial Completion shall be repaired or replaced by the Contractor.

B. The Contractor shall inspect each pipe and fitting prior to installation to ensure that there are no damaged portions of the pipe. No pipe shall be installed where the lining or coating show defects that may be harmful as determined by the Engineer. Such damaged lining or coating shall be repaired, or a new undamaged pipe shall be furnished and installed.

C. The pipe shall be installed in accordance with ANSI/AWWA C600. Before placement of the 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 all pipes and fittings in the trench shall be closed during any interruption to the Work. As pipe laying progresses, the Contractor shall keep the pipe interior free of all debris. The Contractor shall completely clean the interior of the pipe of all sand, dirt, rocks and any other debris following completion of pipe laying prior to testing and disinfecting the completed pipeline.

D. Pipe shall be laid directly on the imported 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 joint 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. 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 the maximum deflection recommended by the pipe manufacturer.

F. 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. No pipe shall be laid unless it can be established that the trench will be backfilled before the formation of ice and frost occurs.

G. The openings of all pipe and specials where the pipe and specials have been cement-mortar lined in the shop 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.

H. Immediately before jointing pipe, the bell end of the pipe shall be thoroughly cleaned and a clean rubber gasket lubricated with an approved vegetable-based lubricant shall be placed in the bell groove. The spigot end of the pipe shall be carefully cleaned and lubricated with a vegetable-based lubricant. 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.

I. All valves shall be handled in a manner to prevent any injury to any part of the valve. All joints shall be thoroughly cleaned and prepared prior to installation. The Contractor shall adjust all stem packing and operate each valve prior to installation to ensure proper operation. All valves shall be installed so that the valve stems are plumb and in the location shown.

K. All buried bolts shall be coated with FM grease prior to applying the polyethylene wrap.

END OF SECTION 400519

SECTION 400531 - PLASTIC PROCESS PIPE

PART 1 - GENERAL

1.1 THE REQUIREMENT:

A. The Contractor shall furnish and install all PVC and polyethylene plastic pipe, fittings, transitions, connections and appurtenant work, complete and in accordance with the requirements of the Contract Documents.

1.2 RELATED WORK SPECIFIED ELSEWHERE:

A. Earth Moving. Section 312000

B. Pipeline Testing. Section 330505

1.3 REFERENCE SPECIFICATIONS, CODES AND STANDARDS:

A. Commercial Standards:

ASTM D 1784 and ASTM D 1785	Specifications for Polyvinyl Chloride (PVC) Plastic Pressure Pipe and Solvents
ASTM D 3034	Specifications for Polyvinyl Chloride (PVC) Plastic Gravity Sewer Pipe
ASTM D 2321	Standard Practice for Underground Installation of Flexible Thermoplastic Sewer Pipe
ASTM F894	Specification for Polyethylene (PE) Large Diameter Profile Wall Sewer and Drain Pipe.
ASTM D3350	Specification for Polyethylene Plastics Pipe and Fittings Materials.

1.4 CONTRACTOR SUBMITTALS:

A. Contractor shall submit copies of the manufacturer's product specifications according to the requirements of Section 013300 entitled, "Contractor Submittals".

PART 2 - PRODUCTS

2.1 PVC (POLYVINYL CHLORIDE) PRESSURE PIPE, 24-INCH DIAMETER AND SMALLER - SOLVENT WELDED

A. PVC pressure pipe 24-inches and smaller shall be made from all new rigid un-plasticized polyvinyl chloride and shall be Normal Impact Class 12454-B, Schedule 80, to conform to ASTM D 1785, unless otherwise shown. Elbows and tees shall be of the same material and schedule as the pipe. Unless otherwise shown, joint design shall be for solvent-welded construction.

B. Solvent welded PVC and CPVC joints shall utilize heavy solvent welding glue, suitable for chemical exposure applications including sodium hypochlorite solution (up to 20%

concentration) and sodium bisulfate solution (up to 50% concentration). Solvents shall meet ASTM F 493, ASTM D 2846, ASTM D 2564 standards and SCAQMD Rule 1168/316A. PVC solvent weld shall be WELD-ON brand as manufactured by IPS Corporation or equal. Installation shall conform to ASMT D-2855 and manufacturer instructions. The following solvents are provided for reference, Contractor shall confirm appropriate installation and application with the solvent supplier:

Up to 12" PVC (schedule 40 or 80): Weld-On 711 & 717
Up to 30" PVC (schedule 40 or 80): Weld On 719
Up to 12" CPVC (schedule 40 or 80): Weld-On 714 & 724
Up to 30" CPVC (schedule 40 or 80): Weld-On 729

C. Contractor shall apply primers (Weld-On P-70) and prepare the solvent welded joints as recommended by the manufacturer.

2.2 CPVC (CHORINATED POLYVINYL CHLORIDE) PRESSURE PIPE, 8-INCHES AND SMALLER – SOLVENT WELDED

D. All CPVC pipe shall be made from all new rigid, un-plasticized Type IV, Grade I Chlorinated Polyvinyl Chloride (CPVC) compound with a cell classification of 23447, Schedule 80, per ASTM D 1784. The pipe shall be manufactured in compliance to ASTM F441, meeting all requirements with regard to material, workmanship, burst pressure, flattening, and extrusion quality.

E. Solvent welded PVC and CPVC joints shall utilize heavy solvent welding glue, suitable for chemical exposure applications. Solvents shall meet ASTM F 493, ASTM D 2846, ASTM D 2564 standards and SCAQMD Rule 1168/316A. PVC solvent weld shall be WELD-ON brand as manufactured by IPS Corporation or equal. Installation shall conform to ASTM D-2855 and manufacturer instructions. The following solvents are recommended by IPS Corporation

Up to 12" PVC (schedule 40 or 80): Weld-On 711 & 717
Up to 30" PVC (schedule 40 or 80): Weld-On 719
Up to 12" CPVC (schedule 40 or 80): Weld-On 714 & 724
Up to 24" CPVC (schedule 40 or 80): Weld-On 729

Contractor shall consult with solvent manufacturer to ensure proper use and application for each pipe size required in the design drawings. Contractor shall apply primers (Weld-On P-70) and prepare the solvent welded joints as recommended by the manufacturer.

2.3 DOUBLE WALL CONTAINMENT PVC AND CPVC PIPING AND FITTINGS – SOLVENT WELDED

A. Contractor shall furnish a complete double-containment piping system including piping, fittings, anchors, terminations, and other appurtenances. Containment piping shall conform to the following standards:

ASTM D 1784
ASTM D 1970
ASTM F 437

ASTM F 439
ASTM F 441

B. All double containment pipe for buried chemical service shall consist of an outer containment pipe of Schedule 80 PVC or CPVC by an inner product pipe of Schedule 80 PVC or CPVC pipe, material as specified in the design drawings and pipe schedules. Containment pipe shall be at least 2 sizes larger than product pipe. Transition to single wall piping must be above the finished grade or floor.

C. Where joining to existing below grade containment lines (pipe in a pipe style containment lines), contractor shall utilize CPVC couplers, bushings, or fittings as necessary to connect the new containment pipe to the existing containment pipe lines. Note that existing lines may utilize different containment line diameter sizes than that of the new containment pipe. Contractor shall coordinate couplings and tie-ins to existing containment pipe with the containment pipe supplier.

D. Containment PVC and CPVC pipe shall be:

1. Asahi/America – Pro-Lock
2. IPS Flow Systems - Duo-Safe
3. Or Equal

E. For transition from double containment below grade service to single wall above grade service, provide a cap to cover and prevent water, debris or other items from falling into the containment pipe.

F. Solvent welded PVC and CPVC joints shall utilize heavy solvent welding glue, suitable for chemical exposure applications. Solvents shall meet ASTM F 493, ASTM D 2846, ASTM D 2564 standards and SCAQMD Rule 1168/316A. PVC solvent weld shall be WELD-ON brand as manufactured by IPS Corporation or equal. Installation shall conform to ASTM D-2855 and manufacturer instructions. The following solvents are recommended by IPS Corporation:

Up to 12” PVC (schedule 40 or 80): Weld-On 711 & 717
Up to 30” PVC (schedule 40 or 80): Weld-On 719
Up to 12” CPVC (schedule 40 or 80): Weld-On 714 & 724
Up to 24” CPVC (schedule 40 or 80): Weld-On 729

Contractor shall consult with solvent manufacturer to ensure proper use and application for each pipe size required in the design drawings. Contractor shall apply primers (Weld-On P-70) and prepare the solvent welded joints as recommended by the manufacturer. Contractor shall also consult with the containment pipe supplier regarding solvent welding procedures.

2.4 AWWA C-900 PLASTIC PIPE (4”-12”)

A. Pipe shall meet the requirements of AWWA C900 “Polyvinyl Chloride (PVC) Pressure Pipe and Fabricated Fittings, 4-Inch through 12-Inch with maximum DR of 18 unless noted otherwise.

B. Provisions must be made for expansion and contraction at each joint with an elastomeric seal.

C. The bell shall consist of an integral thickened wall section with an elastomeric seal. The wall thickness in the bell section shall conform to the requirements of Section 6.2 of ASTM D3139, "Standard Specification for Joint for Plastic Pressure Pipes Using Flexible Elastomeric Seals."

D. When used for potable water systems, pipe shall meet the requirements of ANSI/NSF 61 "Drinking Water System Components – Health Effects."

E. The pipe shall be manufactured to cast iron outside diameters (CIOD) in accordance with AWWA C900.

F. The seal shall meet the requirement of ASTM F477 "Standard for Elastomeric Seals (Gaskets) for Joining Plastic Pipe."

G. All fittings shall be ductile iron fittings, as required in Section 400519.

2.5 AWWA C-905 PLASTIC PIPE (14"-42")

A. Material: PVC compound shall meet Cell Class 12454 per ASTM D 1784 and shall be certified to ANSI/NSF Standard 61 for potability.

B. Pipe shall meet AWWA C905 with a maximum DR of 41 and shall be UL listed.

C. Elastomeric Seal: Integral bell pipe shall be provided with factory-installed gaskets, which meet the requirements of ASTM F 477.

D. Gasketed joint assembly shall meet the requirements of ASTM D 3139.

E. All fittings shall be ductile iron fittings, as required in Section 400519.

2.6 DRAIN WASTE VENT PIPE (PVC DR-35 ½" – 8")

A. Pipe shall be extruded from PVC Compound having a minimum Cell Classification 12454B as defined in ASTM D 1784. Belled end shall conform to ASTM D 2672, "Joints for PVC Pipe Using Solvent Cements", and shall conform to ASTM D 2855.

2.7 RESTRAINED JOINTS

A. Restrained joints shall conform to either ANSI/AWWA C111/A21.11 or ANSI/AWWA C153/A21.53.

B. Restraint devices for pipe sizes 3" – 48" shall consist of multiple gripping wedges incorporated into a follower gland meeting the applicable requirements of ANSI/AWWA C110/A21.10. The devices shall have a working pressure rating of 350 psi for 3"-16" and 250 psi for 18"-48". Ratings are for water pressure and must include a minimum safety factor of 2 to 1 in all sizes.

C. Gland body, wedges and wedge actuating components shall be cast from grade 65-45-12 ductile iron material in accordance with ASTM A536. For applications requiring restraint 30" and greater, an alternate grade of iron meeting the material requirements of ASTM A536 is acceptable, providing the device meets all end product performance requirements. Ductile iron gripping wedges shall be heat treated within a range of 370 to 470 BHN.

D. Three (3) test bars shall be incrementally poured per production shift as per UL specifications and ASTM A536. Testing for tensile, yield and elongation shall be done in accordance with ASTM E8. Chemical and nodularity tests shall be performed as recommended by the Ductile Iron Society, on a per ladle basis.

E. Mechanical joint restraint for PVC pipe shall be:

1. Megalug Series 2000 or 2200 produced by EBAA Iron Inc. or equal for fittings.
2. Megalug Series 1900 or 2800 produced by EBAA Iron Inc. or equal for joints.

F. Finish coating shall be Megabond, or equal.

PART 3 - EXECUTION

3.1 INSTALLATION OF PIPE:

A. All pipe, fittings, etc. shall be carefully handled and protected against damage, impact shocks and free fall. All pipe handling equipment shall be acceptable to the Engineer. Pipe shall not be placed directly on rough ground, but shall be supported in a manner which will protect the pipe against injury whenever stored at the work site. All pipe damaged prior to Substantial Completion shall be repaired or replaced by the Contractor.

B. The Contractor shall inspect each pipe and fitting prior to installation to ensure that there are no damaged portions of the pipe. Damaged pipe shall be replaced with new undamaged sections of pipe.

C. Before placement of the 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 all pipes and fittings in the trench shall be closed during any interruption to the Work. As pipe laying progresses, the Contractor shall keep the pipe interior free of all debris. The Contractor shall completely clean the interior of the pipe of all sand, dirt, rocks and any other debris following completion of pipe laying prior to testing, disinfecting and placing the completed pipeline in service.

D. Pipe shall be laid directly on the imported 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. Bell holes shall be formed at the ends of the pipe to prevent joint loading at the bells or couplings.

E. Where necessary to raise or lower the pipe grade 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 or by the use of additional fittings. However, in no case shall the deflection in the joint exceed the maximum deflection recommended by the pipe manufacturer.

F. No pipe shall be installed upon a foundation into which frost has penetrated or any time that there is a danger of the formation of ice or penetration of frost at the bottom of the excavation. No pipe shall be laid unless it can be established that the trench will be backfilled before the formation of ice and frost occurs.

G. Immediately before jointing bell and spigot pipe, both the bell and spigot end of the pipe shall be thoroughly cleaned and lubricated with an approved vegetable-based lubricant. The spigot end of the pipe section shall then be inserted into the bell of the previously laid joint and telescoped into its proper alignment. Tilting of the pipe to insert the spigot into the bell will not be permitted.

H. Solvent-welded and heat-fused joints shall be carefully and thoroughly cleaned immediately before jointing the pipe. Particular care shall be taken in making solvent-welded joints to ensure a uniform, homogeneous and complete bond.

END OF SECTION 400531

SECTION 400533 - HIGH DENSITY POLYETHYLENE (HDPE) PIPE AND FITTINGS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. The Contractor shall provide high density polyethylene pipe and appurtenances, complete in place, in accordance with the Contract Documents.

1.2 RELATED SECTION

A. Section 312000 – Earth Moving

1.3 REFERENCES

A. The Materials and Work furnished shall be, as a minimum, in accordance with the latest editions of the following standards except as such Standard are modified and supplemented in this section.

AWWA C906	Standard for Polyethylene (PE) Pressure Pipe & Fittings, 4 inch (100 mm) through 63 inch (1,575 mm) for Water Distribution and Transmission
ASTM D1238	Standard Test Method for Melt Flow Rates of Thermoplastics by Extrusion Plastometer
ASTM D1248	Standard Specification for Polyethylene Plastics Extrusion Materials for Wire and Cable
ASTM D1505	Standard Test Method for Density of Plastics by the Density-Gradient Technique
ASTM D2837	Standard Test Method for Obtaining Hydrostatic Design Basis for Thermoplastic Pipe Materials or Pressure Design Basis for Thermoplastic Pipe Products
ASTM F714	Standard Specification for Polyethylene (PE) Plastic Pipe (SDR-PR) Based on Outside Diameter
ASTM D3035	Standard Specification for Polyethylene (PE) Plastic Pipe (DR-PR) Based on Controlled Outside Diameter
ASTM D3261	Standard Specification for Butt Heat Fusion Polyethylene (PE) Plastic Fittings for Polyethylene (PE) Plastic Pipe and Tubing
ASTM D3350	Standard Specification for Polyethylene Plastics Pipe and Fittings Materials
ASTM D256	Standard Test Methods for Determining the Izod Pendulum Impact Resistance of Plastics
ASTM D2683	Standard Specification for Socket-Type Polyethylene Fittings for Outside Diameter-Controlled Polyethylene Pipe and Tubing
ASTM F1055	Standard Specification for Electrofusion Type Polyethylene Fittings for Outside Diameter Controlled Polyethylene Pipe and Tubing
ASTM D2657	Standard Practice for Heat Fusion Joining of Polyolefin Pipe and Fittings
ASTM F2164	Standard Practice for Field Leak Testing of Polyethylene (PE) Pressure Piping Systems Using Hydrostatic Pressure

ASTM F1417	Standard Test Method for Installation Acceptance of Plastic Gravity Sewer Lines Using Low-Pressure Air
PPI TR-33	Generic Butt Fusion Joining Procedure for Field Joining of PE Pipe

1.4 SUBMITTALS

A. The Contractor shall submit the following information and data. See Section 013300 – Contractor Submittals.

1. Product Data: Provide data indicating pipe, pipe accessories and fittings.
2. Manufacturer's Installation Instructions: Indicate special procedures required to install products specified.
3. Manufacturer's Certificate: Certify that products meet or exceed specified requirements.
4. Certified Resin Test Reports covering the physical, stress, regression, thermal and impact tests of resin material to be used for the pipe. Submit this information prior to manufacturing or fabricating any pipe.
5. Proposed butt fusion procedures including training and qualification requirements and joint repair procedures shall be submitted to the Engineer for review and approval.
6. Qualifications of Butt Fusion Welders and Welding Operators
   a. All butt fusion welders and welding operators shall be qualified and certified for all portions of the work specified in this section. Welder qualification requires that during the past 12 months all welders and welding operators have successfully completed certified butt-fusion joints using the pipe and welding machine proposed for this project.
   b. Current welder and welding operator performance qualification test records shall be submitted to the Engineer for review and approval prior to commencing field operations.
   c. Personnel that will be operating the butt fusion welder shall be certified by either 1 and 3, or 2 and 3 of the following criteria:
      1) Previous demonstrated experience during the past 12 months, in the use of the procedure on similar projects using the same welding machines and type of pipe proposed.
      2) Appropriate training and apprenticeship
      3) All operators shall make a specimen joint from the pipe to be used on the project. This joint shall then be subjected to the test requirements specified herein.
7. Fusion parameters including the recommended limits of all criteria recorded by the data logger.
8. Fusion report for each joint, which shall include the following information.
   a. Pipe size and dimensions
   b. Machine size
   c. Operator identification
   d. Job identification number
   e. Weld number
   f. Fusion, heating and drag resistance settings
   g. Heater plate temperature
   h. Time Stamp
   i. Heating and curing time of weld
   j. Curing temperature readings and time stamps of readings
   k. Ambient air temperature and humidity

l. Error message and warnings for out of range temperature or pressure settings.

1.5 REGULATORY REQUIREMENTS

A. Conform to applicable codes for materials and installation of the Work in this Section.

1.6 PROJECT CONDITIONS

A. Coordinate the Work on existing utility lines and connections to existing utility lines with the Owner.

1.7 QUALITY CONTROL

A. Any pipe manufactured prior to review and approval of all required prefabrication submittals will be at the Contractor's own risk.

B. Review of the Contractor's shop drawings shall not relieve the Contractor of any responsibility for accuracy of dimensions and details, nor shall mutual Agreement of dimensions or details relieve the Contractor of responsibility for Agreement and conformity of its Shop Drawings with the Contract.

1.8 QUALITY ASSURANCE

A. Fabrication, processing, testing and inspection operations affecting the pipe and associated accessories shall, at any time, be subject to quality assurance surveillance by Owner, or Engineer. Such surveillance shall be at the discretion of the Owner. Such surveillance does not relieve the Contractor from responsibility for the Work.

B. All deviations from this specification section must be documented and referred to Engineer for resolution.

C. The Contractor shall submit to the Engineer an affidavit from the manufacturer that the pipe, specials, fittings, and other products of material furnished under this Contract comply with all applicable provisions of AWWA C906 standards and this specification.

D. DOCUMENTATION: The following items shall be documented and stored as part of the manufacturer's permanent records. Copies of all documentation shall be provided to the Engineer.

1. Documentation from the resin's manufacturer showing results of the following tests for resin identification:
   a. Standard Test Method for Melt Flow Rates of Thermoplastics by Extrusion Plastometer, ASTM D1238
   b. Standard Test Method for Density of Plastics by the Density - Gradient Technique, ASTM D1505
2. The polyethylene pipe manufacturer shall provide certification that stress regression testing has been performed on the specific polyethylene resin being utilized in the manufacture of this product. This stress regression testing shall have been done in accordance with ASTM D2837 and the manufacturer shall provide a product supplying a minimum Hydrostatic Design Basis (HDB) of 1,600 psi as determined in accordance with ASTM D2837.

3. Production staff shall check each length of pipe produced for the items listed below. The results of all measurements shall be recorded on production sheets, which becomes part of the manufacturer’s permanent records.
   a. Pipe in process shall be checked visually, inside and out for cosmetic defects (grooves, pits, hollows, etc.)
   b. Pipe outside diameter shall be measured using a suitable periphery tape to ensure conformance with ASTM D3035.
   c. Pipe wall thickness shall be measured at 12 equally spaced locations around the circumference at both ends of the pipe to ensure conformance with ASTM D3035.
   d. Pipe length shall be measured.
   e. Pipe marking shall be examined and checked for accuracy.
   f. Pipe ends shall be checked to ensure they are cut square and clean.
   g. Subject inside surface to a “reverse bend test” to ensure the pipe is free of oxidation (brittleness).
   h. Copies of all manufacturer documentation shall be submitted to the Engineer for review and approval upon completion of manufacturing.

E. In addition to those tests specifically required, the Engineer may request additional samples of any material for testing by the Owner. The additional samples shall be furnished as a part of the Work.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS

A. Contractor shall comply with the following minimum requirements:
   1. Referenced standards for all materials, processes, methods, tests, etc to be used in completion of the Work.
   2. Delivery of all pipe and materials, all aspects of which shall be conducted in such a manner as to minimize handling, provide proper weather protection and storage, and to meet schedule requirements.
   3. Furnish and use load rated nylon-type slings for securing, lifting, and unloading pipe sections; or, the use of acceptable protective wraps to minimize damage from the alternate rigging equipment.
   4. Internal timber bracing shall be provided to maintain pipe shape and integrity throughout plant storage, transportation, and site storage operations through installation and backfill placement. Internal bracing shall not be removed until a minimum of 2 feet of compacted trench zone material is placed above the top of the pipe.

2.2 MANUFACTURER

A. All HDPE pipe and HDPE fittings shall be from a single manufacturer, who is fully experienced, reputable and qualified in the manufacture of the HDPE pipe to be furnished. The pipe shall be designed, constructed and installed in accordance with the best practices and methods and shall comply with these Specifications. Qualified manufacturers shall be: PLEXCO Division of Chevron Phillips Chemical Company, DRISCOPIPE as manufactured by Chevron Phillips Co., Inc., WL Plastics or equal.

2.3 PIPE IDENTIFICATION

A. The following shall be continuously indent printed on the pipe or spaced at intervals not exceeding 5-feet:

1. Name and/or trademark of the pipe manufacturer.
2. Nominal pipe size.
3. Dimension ratio.
4. The letters PE followed by the polyethylene grade in accordance with ASTM
5. D1248 followed by the hydrostatic design basis of 1600 psi, e.g., PE 4710.
6. Manufacturing standard reference, e.g., ASTM D-3035, as required.
7. A production code from which the date and place of manufacture can be determined.
8. Color Identification, either striped by co-extruding longitudinal identifiable color markings or shall be solid in color and as follows:
   a. BLUE – Potable Water
   b. GREEN – Sanitary Sewer
   c. PURPLE – Utility Water

B. Marking Tape: Marking tape shall be provided and installed as shown in Drawings and per Engineer approval.

2.4 COMPATIBILITY

A. Contractor is responsible for compatibility between pipe materials, fittings and appurtenances.

2.5 WARRANTY

A. The pipe Manufacturer shall provide a warranty against manufacturing defects of material and workmanship for a period of ten years after the final acceptance of the project by the Owner. The Manufacturer shall replace at no expense to the Owner any defective pipe/fitting material including labor within the warranty period.

2.6 MATERIALS

A. Materials used for the manufacture of polyethylene pipe and fittings shall be made from a PE 4710 high density polyethylene resin compound meeting a minimum cell classification 445574C per ASTM D3350 and ASTM F714.

B. High Density Polyethylene (HDPE) pipe shall be manufactured in accordance with AWWA C901-96 for sizes ½-inch through 3-inch diameters and to the requirements of ASTM D 3035. Pipe 4-inches and above shall be manufactured to the requirements of ASTM F714 and AWWA C906-99.

C. Unless otherwise noted, diameters shown in the Contract Documents shall refer to Iron Pipe Size (IPS) system conforming to the requirements of AWWA C906.

D. If rework compounds are required, only those generated in the Manufacturer's own plant from resin compounds of the same class and type from the same raw material supplier shall be used. Clean rework material of the same type grade, and cell classification generated from the manufacturers own pipe and fitting production may be used by the same manufacturer as long as the pipe, tubing and fittings produced meet all requirements of AWWA C906.

E. Dimensions and workmanship shall be as specified by ASTM F714. HDPE fittings and transitions shall meet ASTM D3261. HDPE pipe shall have a range of density 0.956-0.964 grams per cubic centimeter. All HDPE pipe and fittings shall have a Hydrostatic Design Basis (HDB) of 1,600 psi at 73.0°F in accordance with ASTM D2837.

F. The extruded pipe shall have impact strengths greater than 42 in-lb/in in accordance with ASTM D256 Method A, with a material thickness representative of the cross-section in which the material is to be used.

G. Pipe and fitings used for potable water applications shall be NSF 61 certified.

H. The pipe Manufacturer shall certify compliance with the above requirements.

2.7 FABRICATION

A. Pipe shall be homogenous throughout and uniform in color, opacity, density and other properties as prescribed in the Resin Manufacturers Specifications. The inside and outside surfaces shall be semi-matte to glossy in appearance and free from sticky or tacky material. The pipe walls shall be free from cuts, cracks, holes, blisters, voids, foreign inclusions, or other defects that are visible to the naked eye that may affect wall integrity.

B. Pipe dimensions and wall thickness variations shall be in conformance with requirements of AWWA C906.

C. Pipe shall be finished smooth throughout all inside surfaces and true to all specified tolerances circumference and diameter such that: The difference between maximum and minimum diameters, at any cross-section along the length of the pipe does not exceed 1% of the nominal diameter.

D. Special pipe sections, fittings, and special pieces shall be completely fabricated in the shop. All pipe fittings shall be fabricated or molded to correct dimensions throughout the entire length. Ends cuts shall be clean, squarely-made, and suitable for field welding, without drawn, ragged, gouged, or split ends.

E. All HDPE fittings, unless noted otherwise on the drawings shall be fabricated in conformance with the requirements of AWWA C906. Molded fittings shall meet the requirements of ASTM D3261 for butt-type fittings and this specification.

2.8 FITTINGS

A. All molded fittings and fabricated fittings shall be fully pressure rated to match the pipe SDR pressure rating to which they are made. All fittings shall be molded or fabricated by the manufacturer. No Contractor fabricated fittings shall be used unless approved by the Engineer.

B. Polyethylene fittings furnished under this specification shall be manufactured using compounds complying with the requirements of HDPE pipe above and all appropriate requirements of AWWA C906. Socket fittings shall comply with ASTM D2683, Butt Fusion fittings shall comply with ASTM D3261. Electrofusion fittings shall comply with ASTM F1055. Mechanical fittings (e.g. back-up rings, etc.) shall be of stainless steel, including stainless steel hardware, as indicated in the drawings and shall be approved only after submission of appropriate test data and service histories indicating their acceptability for intended service. In all cases, the specification and requirements for the fittings supplied shall comply with the appropriate sections of AWWA C906 and must be approved by the Engineer. NO size on size wet taps shall be permitted.

C. The manufacturer of the HDPE pipe shall supply all HDPE fittings and accessories as well as any adapters and/or specials required to perform the work as shown on the Drawings and specified herein.

2.9 SHIPPING, STORAGE & HANDLING

A. All materials shall be properly loaded so that they will not bear on each other, and shall be braced to prevent damage to material during shipping. Pipe shall be stacked on level ground and per the manufacturer's recommendations to prevent pipe from becoming out of round.

B. All loose parts shall be crated or boxed for shipping, appropriately identified and shipped with the associated pipe sections.

C. Contractor shall protect pipeline sections stored at the site from damage, including weather and vandalism.

D. Pipes shall be stored on level ground, preferably turf or sand, free of sharp objects, which could damage the pipe OR on wooden sleepers, spaced suitably and of such width as not to allow deformation of the pipe at the point of contact with the sleeper or between supports. Stacking of the polyethylene pipe shall be limited to a height that will not cause excessive deformation of the bottom layers of pipes under anticipated temperature conditions. The Contractor shall abide by the required handling techniques specified by the Supplier.

E. The handling of the pipe shall be in such a manner that the pipe is not damaged by dragging it over sharp and cutting objects

F. All piping products shall be kept free from dirt, grease, all petroleum based products, and other foreign matter.

G. The Contractor shall provide suitable lifting equipment, slings, spreader bars, rigging etc needed to handle the pipe. In no case shall any equipment be used that is not rated to handle the intended loading or conditions of use to which it is subjected. The use of cables and chains is prohibited.

H. The Contractor shall be responsible for the pipe until such time as it is installed and accepted by the Engineer.

I. The Contractor shall remove any temporary attachments to special components for installation by the Supplier for transportation purposes.

2.10 BEDDING AND COVER MATERIALS

A. Pipe bedding Material: As specified in Section 312000 – Earth Moving.

PART 3 - EXECUTION

3.1 INSTALLATION – HDPE PIPING

A. High Density Polyethylene (HDPE) Pipe shall be installed in accordance with the instructions of the manufacturer, as shown on the Drawings and as specified herein. A factory qualified joining technician as designated by the pipe manufacturer shall perform all heat fusion joints.

B. Under no circumstances shall the pipe or accessories be dropped into the trench or forced through a directional bore upon "pull-back".

C. The maximum allowable depth of cuts, scratches or gouges on the exterior of the pipe is 5 percent of wall thickness. The interior pipe surface shall be free of cuts, gouges or scratches. Sections of pipe with cuts, scratches or gouges exceeding 5 percent of the pipe wall thickness shall be removed completely and the ends of the pipeline rejoined. Repair of damaged pipe during or after installation shall conform to the fabricator's repair procedures or by an Engineer approved repair method.

D. When laying pipe is not in progress, the open ends of the pipe shall be closed by fabricated plugs, or by other approved means.

E. The interior of the pipe shall be cleaned of any foreign matter before being lowered in the trench and kept clean during placement, joint welding, bedding and backfilling operations by plugging or other approved method. Groundwater shall not be permitted to enter the pipe. The full length of each pipe section and each bend shall rest solidly on the compacted bedding material.

F. All HDPE pipe must be at the temperature of the surrounding soil at the time of backfilling and compaction.

G. If a defective pipe is discovered after it has been installed, it shall be removed and replaced with a sound pipe in a satisfactory manner at no additional cost to the Owner. All pipe and fittings shall be thoroughly cleaned before installation, shall be kept clean until they are used in the work and when laid, shall conform to the lines and grades required.

H. Contractor shall install HDPE pipe when the ambient air temperature conforms to manufacturer's specifications. The Contractor will be responsible for verifying the temperature by maintaining a log listing dates, times, length of pipe installed and ambient temperature during installation.

I. Trench bottoms shall be graded such that each section of pipe shall be placed to the specified depth or elevation with uniform support. When the bottom of the trench has been excavated below the specified depth or elevation it shall be brought to the specified depth or elevation by backfilling with approved pipe zone material. When material at the bottom of the trench is determined to be unsuitable by the Engineer, it shall be removed and the trench backfilled with approved subgrade material or bedding material to the specified depth of excavation.

J. During pipe installation, the trench bottom shall be kept free of frost, frozen earth, or standing water. The Contractor shall maintain the trench in good, stable condition at all times to prevent caving.

K. Precautions shall be taken to prevent flotation of the pipe in the trench.

L. The pipeline may be buried as it is installed, provided all inspection, testing and backfill requirements are met.

M. All areas disturbed by installation of the pipeline shall be restored in accordance with the specification and drawings.

3.2 JOINING METHOD

A. HDPE pipe shall be joined with butt, heat fusion joints as outlined in ASTM D3261 and conform to the Generic Butt Fusion Joining Procedure for Field Joining of Polyethylene Pipe, Technical Report TR-33, published by the Plastic Pipe Institute (PPI). All joints shall be made in strict compliance with the manufacturer's recommendations. A factory qualified joining technician as designated by pipe manufacturer or experienced, trained technician shall perform all heat fusion joints in the presence of the Inspector. The Contractor shall install the HDPE pipeline complete, including bends, couplings, valves, and other associated fittings and appurtenances as shown on the drawings or specified herein and make all necessary connections to the lines and grades shown on the Drawings and in accordance with these specifications.

B. The Contractor shall furnish all welding equipment and all construction materials and equipment required for lugs, railings, templates, spiders or other supports and internal bracing as may be required to hold the components firmly within the specified tolerances during welding, concrete placement or backfill placement. The contractor shall also furnish and install all necessary positioning devices, ties, pedestals and supports required for installation. Details of such equipment shall be included in the proposed installation procedure to be submitted to the engineer prior to the start of work.

C. Lengths of pipe shall be assembled into suitable installation lengths by the butt-fusion process. All pipes so joined shall be made from the same class and type of raw material made by the same raw material supplier. Pipe shall be furnished in standard laying lengths not to exceed 50 feet and no shorter than 20 feet. Installation shall be in accordance with the requirements of AWWA C906 unless otherwise noted, and the Manufacturer's instructions. Contractor shall be responsible for correct fitting of all pipeline members and components.

D. The polyethylene flange adapters shall be used at pipe material transitions and other locations as indicated in the drawings. The adapters shall be connected together or to other flanges by using a stainless steel "back-up" ring conforming to ANSI B16.1 and shaped as necessary to suit the outside dimensions of the pipe. Ensure that back up rings are in place prior to joining flange adapter to piping or other components. The flange adapter assemblies shall be connected with corrosion resistant bolts and nuts of Type 316 Stainless Steel as specified in ASTM A726 and ASTM A307. All bolts shall be tightened to the manufacturer's specified torques. Bolts shall be tightened alternatively and evenly. After installation apply a non-oxide grease coating to bolts and nuts.

E. Where indicated, sleeve couplings shall be used to make HDPE joints. When sleeve couplings are used, stainless steel (Type 316), pipe stiffeners shall be inserted inside of each HDPE pipe end as recommended by the manufacture to prevent the pipe from going out of round and to ensure a leak free joint. Sleeve couplings shall be specifically rated for service with HDPE pipe and shall be as specified in the Contract Documents. Sleeve coupling shall only be used where indicated in the plans and in conjunction with an HDPE Pipe Anchor Block.

3.3 PREPARATION

A. Butt-fusion welded joints: Refer to Manufacturers recommended procedures. All joints formed by butt fusion processes shall be completed in strict accordance with the Manufacturers specified procedures, except where specifically called out in the specifications or drawings. Minimum requirements for butt-fusion welded joints are as follows:
   1. Pipe ends shall be made clean and square prior to fitting and alignment
   2. Care shall be taken to assure a clean work area, free from airborne dust, moisture, or other foreign matter which may contaminate the finished weld.
   3. All internal surfaces of the pipe shall be maintained clean following completion of a weld and prior to starting the next joint.
   4. All butt-fusion joints shall be water tight under the maximum internal pressure.

3.4 BACKFILL PLACEMENT

A. Pipe zone material shall be placed in accordance with Section 312000 – Earth Moving. Care shall be taken to ensure that the material is carefully worked and compacted into the area beneath and around the pipe to provide continuous support to the pipe. Material shall be properly haunched to provide support. Care shall be taken to avoid movement of the pipe during placement and compaction of the bedding material. Pipe bedding shall be placed to the limits shown on the drawings.

B. Trench backfill shall be placed in accordance with section 312000 – Earth Moving.

C. No construction vehicles or ride-on mechanical compaction equipment shall be permitted to travel over the pipe until a minimum of 2 feet of trench backfill is placed above the top of the pipe.

3.5 CONNECTION TO EXISTING

A. Mechanical connections of the polyethylene pipe to auxiliary equipment such as valves, pumps and tanks shall be through flanged connections which shall consists of the following:
   1. A polyethylene flange adapter shall be thermally butt-fused to the stub end of the pipe.
   2. A Type 316 stainless steel back up ring shall mate with the polyethylene flange adapter.
   3. Type 316 stainless steel bolts and nuts shall be used to complete the connection.
   4. Flange connections shall be provided with a full-face neoprene gasket.

B. All transitions from HDPE pipe to ductile iron or PVC shall be made per the approval of Engineer and per the HDPE pipe manufacturer's recommendations and specifications. A molded flange connector adapter with a back-up ring assembly shall be used for pipe type transitions. Ductile iron back-up rings shall mate with cast iron flanges per ANSI B16.1. A type 316 stainless steel back-up ring shall mate with a type 316 stainless steel flange per ANSI B16.1 and shall be used in all buried applications.
   1. Transition from HDPE to ductile iron fittings and valves shall be approved by Engineer before installation.
   2. No solid sleeves couplings shall be allowed between such material transitions.
   3. The pipe supplier must certify compliance with the above requirements

C. Prior to making connections to any existing structure or pipe, ensure that new pipe has had the time required to acclimate to the buried conditions. Make the appropriate adjustments required by the thermal expansion and contraction properties of HDPE materials before connecting to any dissimilar material or structure.

3.6 FIELD QUALITY CONTROL

A. On days butt fusions are to be made, the first fusion shall be a trial fusion in the presence of the Inspector. The following shall apply:

1. Heating plates shall be inspected for cuts and scrapes. The plate temperature shall be measured at various locations to ensure proper heating/melting per manufacturer's recommendations and as approved by the Inspector.
2. The fusion or test section shall be cut out after cooling completely for inspection.
3. The test section shall be 12" or 30 times (minimum) the wall thickness in length and 1" or 1.5 times the wall thickness in width (minimum).
4. The joint shall be visually inspected as to continuity of "beads" from the melted material, and for assurance of "cold joint" prevention (i.e. – joint shall have visible molded material between walls of (pipe). Joint spacing between the walls of the two ends shall be a minimum of 1/16" to a maximum 3/16".

3.7 TOLERANCES

A. The centerline of the pipe shall not deviate from a straight line drawn between the centers of the openings at the ends of the pipe by more than 1/16-in per foot of length. If a piece of pipe fails to meet this requirement check for straightness, it shall be rejected and removed from the site. Laying instructions of the manufacturer shall be explicitly followed. Good alignment shall be preserved during installation. Deflection of the pipe shall occur only at those places on design drawings and as approved by the Engineer. Fittings, in addition to those shown on the Drawings, shall be used only if necessary or required by the Engineer.

3.8 CLEANING

A. Do not allow dirt, grease, mud, groundwater, tools, equipment and all other foreign matter to enter the pipe at any point during construction.

B. All pipes shall be completely flushed at a rate with water velocities no less than 4.0 feet per second for pipes up to 12 inches in diameter and 3.0 feet per second for all other pipes. For large diameter pipes, alternate methods, including pigging, of cleaning the pipe may be proposed by the Contractor, subject to the approval of the Engineer, provided proposed method will provide a clean pipe equivalent to flushing as determined by the Engineer.

C. No debris, rubbish, dirt, rocks, or other foreign material shall be permitted to enter downstream sections of the pipeline or system.

D. Furnish, install and permanently remove all cross-connections, piping, valving, ports, etc required to complete the cleaning process. Obtain approval of the Engineer prior to adding any components to the pipeline.

3.9 HYDROSTATIC PRESSURE TESTING

A. Hydrostatic pressure testing shall be conducted per the requirements of ASTM F 2164 and these specifications.

B. All HDPE mains shall be field-tested. Contractor shall supply all labor, equipment, material, gages, pumps, plugs, meters and incidentals required for testing. Each main shall be pressure tested upon completion of the pipe laying and backfilling operations, including placement of any required temporary roadway surfacing.

C. Submit a plan for testing, including schedule, method for water conveyance, control, and disposal, to the Engineer for review at least 10 days before starting the test and notify the Engineer a minimum of 48 hours prior to test

D. The maximum test pressure shall be as indicated in the Drawings but shall not exceed 150 percent of the maximum working pressure of the pipe or the design pressure of any component on the pipe, whichever is less.

E. The test temperature of the piping and the test liquid (water) shall not exceed 73 degrees F. or the temperature related to the pressure rating of the pipe as reported by the manufacturer.

F. Test equipment, preparations and procedures shall implicitly follow the requirements of ASTM F 2164 and the Manufacturer's recommendations.

G. In preparing for test, fill line slowly with water. Maintain flow velocity less than 2 feet per second or less than the capacity of any air release devices use to expel trapped air, whichever is less.

H. Expel air completely from the line during filling and again before applying test pressure. Air shall be expelled by means of taps at points of highest elevation. Any taps installed solely for the purpose of releasing trapped air shall be permanently capped at the conclusion of the test.

I. Once all air is expelled and all testing equipment and pipeline components are adequately braced, gradually increase the pressure in the pipeline to the required maximum test pressure. Hold test pressure for four hours adding make-up water as required to maintain the noted maximum test pressure.

J. After the four hour equalization period, reduce pressure in the pipeline by 10 psi to the test pressure and monitor the pressure for 1 hour. Do not increase the pressure or add make-up water during this time.

K. During and after the one-hour test period, observe all components, joints, fittings, and appurtenances of the pipeline for visible signs of leakage. Any visible signs of leakage indicate a failed test, all such leaks shall be repaired and pipeline retested before pipeline will be accepted. If any visible signs of leakage in any butt-fusion joints in the pipe are noted, immediately stop the test and carefully release the test pressure. Repair the noted leaks and restart test procedure from beginning.

L. A successful hydrostatic pressure test will be indicated by no visible signs of leakage and a steady pipeline pressure within 5 psi of the test pressure throughout the one hour test period without increasing the pressure or the addition of make-up water.

M. Upon completion of the test, the pressure shall be bled off from a location other than the point where the pressure is monitored. The pressure drop shall be witnessed by the Engineer at the point where the pressure is being monitored and shall show on the recorded pressure read-out submitted to the Engineer.

N. Repair and/or replace any failed pipeline sections, components, fittings, valves or other appurtenances to the satisfaction of the Engineer and at no additional expense to the Owner.

3.10 LOW PRESSURE AIR TESTING

A. HDPE pipelines intended for use as air ducts shall be tested for leakage prior to placing the pipe in service. Air test shall not be used for acceptance of any HDPE pipeline except those indicated herein or in the Drawings. Furnish, install and completely remove all fittings, branches, plugs, valves and other appurtenances required to complete the testing process.

B. Prior to beginning air test, HDPE pipeline shall be isolated from pipeline components not rated for the air pressures called for in the test.

C. Low pressure air testing shall be completed per the requirements of ASTM F1417 as given in Section 221066 – Pipeline Testing.

D. Pipeline shall be inspected for all visible infiltration leaks as evidenced by infiltrating groundwater. Leaks shall be located and repaired at no additional cost to the Owner and to the satisfaction of the Engineer.

3.11 MANDREL TESTING

A. After successful completion of hydrostatic test, mandrel test all buried HDPE piping.

B. Mandrel configuration: Rigid with circular cross-section with a diameter of not less than 95% of the average inside diameter of the pipeline with a length of circular proportion equal to the nominal diameter of the pipeline.

C. Mandrel pulling method shall be by hand, rope or as directed by the Engineer.

END OF SECTION 400533

SECTION 400562 - PLUG VALVES

PART 1 - GENERAL

1.1 SUMMARY

A. The Contractor shall provide plug valves and appurtenances, complete and operable, in accordance with the Contract Documents.

B. The requirements of Section 400551 - Valves, General apply to this Section.

C. The requirements of Section 400557 - Valve and Gate Actuators apply to this Section.

D. Plug valves shall have undergone a proof-of-design test to demonstrate that the valve components operate at the service flow, pressure, temperature, and fluid conditions, free from binding, excessive noise, and premature failures. Proof-of-design test results shall be available to the Engineer on request. The proof-of-design test shall be conducted in accordance with the applicable provisions of AWWA C517.

1.2 CONTRACTOR SUBMITTALS

A. Furnish submittals in accordance with Section 400551.

PART 2 - PRODUCTS

2.1 GENERAL

A. Plug Valves shall be quarter-turn, non-lubricated with resilient encapsulated plug. Valves shall have port areas of not less than 100% of pipe area.

B. Standards, Approvals and Verification:
1. Valves shall be designed, manufactured and tested in accordance with American Water Works Association Standard ANSI/AWWA C517.
2. All Plug Valves shall be certified Lead-Free in accordance with NSF/ANSI 372.
3. Manufacturer shall have a quality management system that is certified to ISO 9001 by an accredited, certifying body.

C. Connections:
1. Threaded valves shall have threaded NPT full size inlets. The connection shall be hexagonal for a wrench connection.
2. Flanged valves shall have flanges with drilling to ANSIB16.1, Class 125.
3. Mechanical Joint valves shall fully comply with ANSI/AWWA C111/A21.11.

D. Manufacture:
1. Manufacturer shall demonstrate a minimum of ten (10) years' experience in the manufacture of plug valves. When requested, the manufacturer shall provide test certificates, dimensional drawings, parts list drawings and operation and maintenance manuals.

2. The exterior of the valve for above ground service shall be coated with a universal alkyd primer. Valve exterior for buried service shall be coated with an epoxy coating.
3. Valve shall be marked with the Serial Number, Manufacturer, Size, Cold Working Pressure (CWP) and the Direct and Reverse Actuator Pressure Ratings on a corrosion resistant nameplate.
4. Acceptable Manufacturers:
    a. Valmatic (Basis of Design)
    b. DeZurik
    c. Or equal

2.2 ECCENTRIC PLUG VALVES (1/2-INCH TO 3-INCHES)

A. Design:
1. Threaded valve seat shall be a machined seating surface.
2. 2 ½ in. valves and larger shall have a valve seat that is a welded overlay of 95% pure nickel applied directly to the body on a pre-machined, cast seating surface and machined to a smooth finish.
3. Threaded valves shall have shaft seals which consist of V-type lip seal in a fixed gland with a resilient O-ring spring.
4. 2 ½ in. valves and larger shall have shaft seals which consist of V-type packing in a fixed gland with an adjustable follower designed to prevent over compression of the packing and to meet design parameter of the packing manufacturer. Removable POP™ shims shall be provided under the follower flanges to provide for adjustment and prevent over tightening.
5. Permanently lubricated, radial shaft bearings shall be supplied in the upper and lower bearing journals. Thrust bearings shall be provided in the upper and lower journal areas, except for threaded type which only have upper thrust bearings.
6. Both the packing and bearings in the upper and lower journals shall be protected by a Grit-Guard™ "drip tight" Buna-N shaft seal located on the valve shaft to minimize the entrance of grit into the bearing journal and shaft seal areas.
7. The threaded valve body shall have 1/8" NPT upstream and downsteam pressure ports.

B. Materials:
1. Valve bodies and covers shall be constructed of ASTM A126 Class B cast iron for working pressures up to 175 psig and ASTM A536 Grade 65-45-12 for working pressures up to 250 psig. The words "SEAT END" shall be cast on the exterior of the body seat end.
2. Threaded valve plugs shall be of one-piece construction and made of ASTM A126 Class B cast iron fully encapsulated with a resilient facing per ASTM D2000-BG and ANSI/AWWA C517 requirements.
3. 2 ½ in. plugs and larger shall be of one-piece construction and made of ASTM A126 Class B cast iron or ASTM A536 Grade 65-45-12 ductile iron and fully encapsulated with resilient facing per ASTM D2000-BG and ANSI/AWWA C517 requirements.
4. Threaded valves shall have radial shaft bearings constructed of self-lubricating Type 316 stainless steel. The top thrust bearing shall be Teflon.
5. 2 ½ in. plug valves and larger shall have radial shaft bearings constructed of self-lubricating Type 316 stainless steel. The top thrust bearing shall be Teflon. The bottom thrust bearing shall be self-lubricating Type 316 stainless steel. Cover bolts shall be corrosion resistant with zinc plating.

C. Actuators:
1. Threaded valves shall be equipped with a hand lever with a dial indicator and open memory stop.

2. Valves 2 ½ in. and larger shall be equipped with a 2-inch square nut for direct quarter turn operation. The packing gland shall include a friction collar and an open position memory stop. The friction collar shall include a nylon sleeve to provide friction without exerting pressure on the valve packing.
3. All gear actuators shall be designed to withstand, without damage, a rim pull of 200 lb. on the hand wheel and an input torque or 300 ft-lbs. for nuts.
4. Buried service actuators shall be packed with grease and sealed for temporary submergence to 20 feet of water. Exposed worm shafts shall be stainless steel.

2.3 ECCENTRIC PLUG VALVES (3-INCHES TO 54-INCHES)

A. Design:
1. Valves shall have a valve seat that is a welded overlay of 95% pure nickel applied directly to the body on a pre-machined, cast seating surface and machined to a smooth finish.
2. Valves shall have shaft seals which consist of V-type packing in a fixed gland with an adjustable follower and removable shims under the follower flange to provide for adjustment and prevent over compression.
3. Permanently lubricated, radial shaft bearings shall be supplied in the upper and lower bearing journals to eliminate the need for grease fittings. Thrust bearings shall be provided in the upper and lower journal areas, except for threaded type which only have upper thrust bearings.
4. Both the packing and bearings in the upper and lower journals shall be protected by Buna-N shaft seals located on the valve shaft to minimize the entrance of grit into the bearing journal and shaft seal areas.

B. Materials:
1. Valve bodies and covers shall be constructed of ASTM A126 Class B for working pressures up to 175 psig. The words “SEAT END” shall be cast on the exterior of the body seat end.
2. Plugs shall be of one-piece construction and made of ASTM A536 Grade 65-45-12 ductile iron and fully encapsulated with resilient facing per ASTM D2000-BG and ANSI/AWWA C517 requirements.
3. Plug valves shall have radial shaft bearings constructed of self-lubricating Type 316 stainless steel. The thrust bearings shall be PTFE. Cover bolts shall be corrosion resistant with zinc plating.

C. Actuation:
1. Valves shall be equipped with a 2 inch square nut for direct quarter turn operation with a hand lever. The packing gland shall include a friction collar and an open position memory stop. The friction collar shall include a nylon sleeve to provide friction without exerting pressure on the valve packing.
2. Valves shall include a totally enclosed and sealed worm gear actuator with position indicator (above ground service only) and externally adjustable open and closed stops. The worm segment gear shall be ASTM A536 Grade 65-45-12 ductile iron with a precision bore and keyway for connection to the valve shaft. Bronze radial bearings shall be provided for the segment gear and worm shaft. Alloy steel roller thrust bearings shall be provided for the hardened worm.
3. All gear actuators shall be designed to withstand, without damage, a rim pull of 200 lb. on the hand wheel and an input torque or 300 ft-lbs. for nuts.
4. Buried service actuators shall be packed with grease and sealed for temporary submergence to 20 feet of water. Exposed worm gear shafts shall be stainless steel.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Plug valves shall be installed in strict accordance with the manufacturer's published recommendations.

B. Eccentric Plug Valves: Unless otherwise directed, the following rules shall be observed for the installation of eccentric plug valves on sewage, sludge, or other liquid systems containing solids, silt, or fine sand:
   1. The valves shall be positioned with the stem in the horizontal direction.
   2. In horizontal pipelines, the plug shall swing upwards when opening, to permit flushing out of solids.
   3. The orientation of the valve shall prevent the valve body from filling up with solids when closed; however, where the pressure differential through the valve exceeds 25 psi, the higher pressure for valves without worm gear, electric, or air operators shall be through the valve to force the plug against the seat.
   4. Valves which may be closed for extended periods (stand-by, bypass, or drain lines) and valves with reversed flow (higher pressure on downstream side, forcing the plug away from its seat), shall be equipped with worm gear operators for the full range of sizes.
   5. For special applications or when in doubt, consult with the manufacturer prior to installation.

C. Except as otherwise indicated, comply with the following requirements:
   1. Install valves where required for proper operation of piping and equipment, including valves in branch lines where necessary to isolate sections of piping. Locate valves so as to be accessible and so that separate support can be provided when necessary.
   2. Install valves with stems pointed up, in vertical position where possible, but in no case with stems pointed downward from horizontal plane.

D. Insulation: Where insulation is indicated, install extended-stem valves, arranged in proper manner to receive insulation.

E. Valve System: Select and install valves with outside screw and yoke stems, except provide inside screw non-rising stem valves where headroom prevents full opening of OS&Y valves.

F. Renewable Seats: Select and install valves with renewable seats, except where otherwise indicated.

G. Locate all valves in locations which will allow easy operation and facilitates maintenance.

H. Provide chain operators for any valves located more than 8 feet above finished floor. This means double acting lever handles for quarter turn valves, or chain wheels for multi-turn valves. Arrange valves and set up chain length for proper operation.

3.2 ADJUSTING AND CLEANING:

A. Valve Adjustment: After piping systems have been tested and put into service, but before final testing, adjusting, and balancing, inspect each valve for possible leaks. Adjust or replace packing to stop leaks, replace valve if leak persists.

B. Valve Identification: Tag each valve in accordance with Division-22 section "Identification for

Piping and Equipment".

3.3 MANUFACTURER'S CUSTOMER SERVICE

A. Manufacturer's authorized representative shall be available for customer service during installation and start-up, and to train personnel in the operation, maintenance and troubleshooting of the valve.

B. Manufacturer shall also make customer service available directly from the factory in addition to authorized representatives for assistance during installation and start-up, and to train personnel in the operation, maintenance and troubleshooting of the valve.

END OF SECTION

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SECTION 400565 - VALVES FOR PUMP CONTROL AND CHECK SERVICE

PART 1 - GENERAL

1.1 SUBMITTALS

A. Product Data: Submit manufacturer's technical product data, including installation instructions for each type of valve. Include pressure drop curve or chart for each type and size of valve.

B. Shop Drawings: Submit manufacturer's assembly-type (exploded view) shop drawings for each type of valve, indicating dimensions, weights, materials, and methods of assembly of components.

C. Maintenance Data: Submit maintenance data and spare parts list for each type of valve. Include this data, product data, shop drawings in maintenance manual; in accordance with requirements of Division 1.

1.2 QUALITY ASSURANCE

A. Supplier shall have at least ten (10) years' experience in the manufacture of knife gate valves utilizing elastomer cartridge seats, and shall provide references and a list of installations upon request.

B. Valve Identification: Provide valves with manufacturer's name (or trademark) and pressure rating clearly marked on valve body.

C. Codes and Standards:
   1. MSS Compliance: Mark valves in accordance with MSS-25 "Standard Marking System for Valves, Fittings, Flanges and Unions".
   2. ANSI Compliance: For face-to-face and end-to-end dimensions of flanged- or welded-end valve bodies, comply with ANSI B16.10 "Face-to-Face and End-to-End Dimensions of Ferrous Valves".

PART 2 - PRODUCTS

2.1 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 B 763 - Copper Alloy Sand Castings for Valve Application, or ASTM B 584 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 B 16 - 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 Company
   3. Stockham Valves and Fittings
   4. Wm. Powell Company

2.2 PLASTIC BALL CHECK VALVES

A. General: Plastic ball check valves for corrosive fluids, in sizes up to 4-inches, shall be used for vertical up-flow conditions only, unless the valves are provided with spring actions.

B. Construction: The valve bodies and balls shall be of polyvinyl chloride (PVC), chlorinated polyvinyl chloride (CPVC), polyvinylidene fluoride (PVDF), or polypropylene (PP) construction, as best suited for each individual service condition. They shall have unions with socket connections or flanged ends conforming to ASME B16.5 - Pipe Flanges and Flanged Fittings, class 150. Seals shall have Viton O-rings, and valve design shall minimize possibility of the balls sticking or chattering. The valves shall be suitable for a maximum working non-shock pressure of 150 psi at 73 degrees F.

C. Manufacturers, or Equal
   1. ASAHI-AMERICA
   2. George Fischer, Inc.
   3. NIBCO Inc. (Chemtrol Division)
   4. Spears Mfg. Co. (PVC, CPVC, AND PP only)

2.3 PLASTIC SWING OR WYE-CHECK VALVES

A. General: Plastic swing or wye-check valves for corrosive fluids, in sizes up to 8-inches or as available, may be used for horizontal or vertical up-flow conditions.

B. Construction: The valve bodies and discs or piston shall be of PVC, PP, or PVDF construction as best suited for each individual service condition. They shall have flanged ends conforming to ASME B16.5 Class 150, and flanged top access covers and shall shut positively at no-flow conditions. The seats and seals shall be of EPDM, Teflon, or Viton. The PVC valves shall be rated for a maximum non-shock working pressure of 150 psi at 73 degrees F for sizes 3-inches and smaller. For larger sizes and other materials and temperatures the pressure rating may be lower.

C. Manufacturers, or Equal
   1. Valmatic (Swing Flex)
   2. ASAHI-AMERICA
   3. George Fischer, Inc.
   4. Spears Mfg. Co. (Plastic Swing Check only)

2.4 SWING – FLEX CHECK VALVES

A. Scope
   1. This section covers the design, manufacture, and testing of 2 in. through 48 in. Swing-Flex Check Valves suitable for cold working pressures up to 250 psig, in water, wastewater, abrasive, and slurry service.
   2. The check valve shall be of the full flow body type, with a domed access cover and only one moving part, the flexible disc.

B. Standards and Approvals

1. The valves shall be designed, manufactured, tested and certified to American Water Works Association Standard ANSI/AWWA C508.
2. The valves used in potable water service shall be certified to NSF/ANSI 61 Drinking Water System Components – Health Effects, and certified to be Lead-Free in accordance with NSF/ANSI 372.
3. Manufacturer shall have a quality management system that is certified to ISO 9001 by an accredited, certifying body.

C. Connections

1. The valves shall have flanges with drilling to ANSI B16.1, Class 125.

D. Design

1. The valve body shall be full flow equal to nominal pipe diameter at all points through the valve. The 4 in. valve shall be capable of passing a 3 in. solid. The seating surface shall be on a 45 degree angle to minimize disc travel. A threaded port with pipe plug shall be provided on the bottom of the valve to allow for field installation of a backflow actuator or oil cushion device without special tools or removing the valve from the line.
2. The top access port shall be full size, allowing removal of the disc without removing the valve from the line. The access cover shall be domed in shape to provide flushing action over the disc for operating in lines containing high solids content. A threaded port with pipe plug shall be provided in the access cover to allow for field installation of a mechanical, disc position indicator.
3. The disc shall be of one-piece construction, precision molded with an integral O-ring type sealing surface and reinforced with alloy steel. The flex portion of the disc contains nylon reinforcement and shall be warranted for twenty-five years. Non-Slam closing characteristics shall be provided through a short 35 degree disc stroke and a memory disc return action to provide a cracking pressure of 0.25 psig.
4. The valve disc shall be cycle tested 1,000,000 times in accordance with ANSI/AWWA C508 and show no signs of wear, cracking, or distortion to the valve disc or seat and shall remain drop tight at both high and low pressures.

E. Materials

1. The valve body and cover shall be constructed of ASTM A536 Grade 65-45-12 ductile iron or ASTM A126 class B gray iron for 30 in. (800mm) and larger. Optional body materials include ASTM A-351 Grade CF8M, stainless steel for sizes 3" (80 mm) through 12" (300 mm).
2. The disc shall be precision molded Buna-N (NBR), ASTM D2000-BG. Optional disc material includes Viton, EPDM, Hypalon.

F. Manufacture

1. Manufacturer shall demonstrate a minimum of five (5) years' experience in the manufacture of resilient, flexible disc check valves with hydraulic cushions.
2. All valves shall be hydrostatically tested and seat tested to demonstrate zero leakage. When requested, the manufacturer shall provide test certificates, dimensional drawings, parts list drawings, and operation and maintenance manuals.
3. The exterior and interior of the valve shall be coated with an NSF/ANSI 61 approved fusion bonded epoxy coating.
4. Swing-Flex® Check Valves shall be Series #500 as manufactured by Val-Matic® Valve & Mfg. Corporation, Elmhurst, IL. USA or equal.

2.5 DUAL DISK CHECK VALVES

A. Scope
   1. This specification covers the design, manufacture, and testing of 2 in. through 12 in. dual disc check valves suitable for pressures up to 250 psig water service.
   2. The check valve shall be of the dual disc, wafer style with torsion spring induced closure.

B. Standards, approvals and verification
   1. The valves shall be designed, manufactured and tested in accordance with American Water Works Association standard ANSI/AWWA C518.
   2. The valves for use in fire protection systems shall be Underwriters Laboratories listed and Factory Mutual approved in sizes 2 1/2"-12".
   3. The valves shall be certified to be lead-free in accordance with NSF/ANSI 61, Annex G.
   4. Manufacturer shall have a quality management system that is certified to ISO 9001 by an accredited, certifying body.

C. Connections
   1. Wafer style valves shall be provided in sizes 2 in through 12 in for installation between ANSI B16.1 Class 125 iron flanges, or between ISO 7005-2 PN10 or PN16 flanges. Grooved end valves shall be provided in 2" through 12" for installation on pipe with cut grooves per ANSI/AWWA C606 for steel IPS pipe.

D. Design
   1. The body shall be of one-piece construction incorporating a vulcanized synthetic seal.
   2. Seal design shall include a raised sealing bead for positive seating at both high and low pressures. The disc shall fully overlap the synthetic seal, preventing pressure indentations.
   3. Opening and closing of the valve shall utilize a lift and pivot action to prevent seal wear and ensure long seal life.
   4. Disc stabilization in the full open position shall be provided by the use of a stop pin.
   5. The stop and pivot pins shall be stabilized by the use of synthetic spheres to prevent wear due to vibration during operating conditions. The design shall incorporate a raised seat and 1/2" body wall to disc clearance to ensure proper operation after long periods of inactivity and potential corrosion buildup.
   6. Cv flow coefficients shall be equal to or greater than specified below and verified by an independent testing laboratory.

Valve	Cv	
Size	Wafer	Grooved
2 in	76	77
2.5 in	161	129
3 in	224	209
4 in	400	358
5 in	648	573
6 in	1060	898
8 in	1890	1740
10 in	3340	3180
12 in	5270	4950

   8. Closure shall be assisted with a torsion spring to provide a cracking pressure of 0.25 psig.

E. Materials

1. The valve body shall be constructed of astm a536 grade 65-45-12 ductile iron.
2. The disc shall be constructed of astm b584, alloy c87600 (2”-12”) cast bronze. The pivot pins and stop pins shall be type 316 stainless steel.
3. The torsion spring shall be astm a313 type 316 stainless steel.
4. The seal shall be buna-n per astm d2000-bg.

F. Manufacture

1. The valves shall be hydrostatically tested at 2 times their rated cold working pressure. A seat closure test at 2 times the valve rating shall be conducted to demonstrate zero leakage. Additional tests shall be conducted per awwa, ansi, mss or api standards when specified. When requested, the manufacturer shall provide test certificates, dimensional drawings, parts list drawings, and operation and maintenance manuals.
2. The exterior of the valve shall be coated with a universal alkyd primer.
3. Check valves shall be series #8800w (wafer style) and series #8800g (grooved end) as manufactured by val-matic® valve & mfg. Corporation, elmhurst, il. Usa or approved equal.

2.6 SUCTION LINE FOOT VALVES

A. Scope

1. This section covers the design, manufacture, and testing of 2 in. through 42 in. Sure Seal Foot Valves suitable for pressures up to 200 psig water service.
2. The Foot Valve shall be of the full flow globe style designed to provide silent operation, positive seating, and full flow area.

B. Standards, Approvals and Verification

1. The valves shall be certified to be Lead-Free in accordance with NSF/ANSI 61, Annex G.
2. Manufacturer shall have a quality management system that is certified to ISO 9001 by an accredited, certifying body.

C. Connections

1. The Foot Valves shall be provided with flanges in accordance with ANSI B16.1 for Class 125 iron flanges.

D. Design

1. The valve design shall incorporate a center guided disc, guided at opposite ends and having a short linear stroke that generates a flow area equal to the pipe size.
2. All component parts shall be field replaceable without the need of special tools. A replaceable guide bushing shall be provided and held in position by threaded bushing retainer.
3. The valve disc shall be concave to the flow direction providing for disc stabilization, maximum strength, and a minimum flow velocity to open the valve.
4. The valve disc and seat shall have a seating surface finish of 32 micro-inch or better to ensure positive seating at all pressures. A Buna-N seal shall be provided on the seat to provide for zero leakage at both high and low pressures without overloading or damaging the seal. The seal design shall provide both a metal to metal and a metal to Buna-N seal.
5. A heavy-duty basket type screen shall be bolted to the inlet flange outside diameter and provide 3-4 times the pipe area.

E. Materials

1. The valve body shall be constructed of ASTM A126 Class B cast iron.
2. The seat and plug shall be ASTM A351 Grade CF8M stainless steel.
3. The basket screen shall be stainless steel, Type 304.

F. Manufacture
   1. The valves shall be hydrostatically tested at 1.5 times their rated cold working pressure. Additional tests shall be conducted per AWWA, ANSI, MSS or API standards when specified. When requested, the manufacturer shall provide test certificates, dimensional drawings, parts list drawings, and operation and maintenance manuals.
   2. The exterior of the valve shall be coated with a universal alkyd primer.
   3. Foot Valves shall be Series #1900 as manufactured by Val-Matic® Valve & Mfg. Corporation, Elmhurst, IL. USA or equal.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Valve shall be installed in accordance with manufacturer’s written Installation and Operation Manual and approved submittals.

B. Except as otherwise indicated, comply with the following requirements:
   1. Install valves where required for proper operation of piping and equipment, including valves in branch lines where necessary to isolate sections of piping. Locate valves so as to be accessible and so that separate support can be provided when necessary.
   2. Install valves with stems pointed up, in vertical position where possible, but in no case with stems pointed downward from horizontal plane.

C. Insulation: Where insulation is indicated, install extended-stem valves, arranged in proper manner to receive insulation.

D. Renewable Seats: Select and install valves with renewable seats, except where otherwise indicated.

3.2 ADJUSTING AND CLEANING:

A. Valve Adjustment: After piping systems have been tested and put into service, but before final testing, adjusting, and balancing, inspect each valve for possible leaks. Adjust or replace packing to stop leaks, replace valve if leak persists.

B. Valve Identification: Tag each valve in accordance with Division-22 section "Identification for Piping and Equipment".

3.3 VALVE INSTALLATION:

A. Locate all valves in locations which will allow easy operation and facilitates maintenance.

3.4 MANUFACTURER’S CUSTOMER SERVICE

A. Manufacturer’s authorized representative shall be available for customer service during installation and start-up, and to train personnel in the operation, maintenance and troubleshooting of the valve.

B. Manufacturer shall also make customer service available directly from the factory in addition to authorized representatives for assistance during installation and start-up, and to train personnel in the operation, maintenance and troubleshooting of the valve.

END OF SECTION

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SECTION 400567 – BALL VALVES

PART 1 - GENERAL

1.1 SCOPE:

A. Furnish and install all valves complete and in accordance to the requirements of the Contract Documents.

1.2 SUBMITTALS:

A. Product Data: Submit manufacturer's technical product data, including installation instructions for each type of valve. Include pressure drop curve or chart for each type and size of valve.

B. Shop Drawings: Submit manufacturer's assembly-type (exploded view) shop drawings for each type of valve, indicating dimensions, weights, materials, and methods of assembly of components.

C. Maintenance Data: Submit maintenance data and spare parts list for each type of valve. Include this data, product data, shop drawings in maintenance manual; in accordance with requirements of Division 1.

1.3 QUALITY ASSURANCE:

A. Manufacturer's Qualifications: Firms regularly engaged in manufacture of valves, of types and sizes required, whose products have been in satisfactory use in similar service.

B. Valve Types: Provide valves of same type by same manufacturer.

C. Valve Identification: Provide valves with manufacturer's name (or trademark) and pressure rating clearly marked on valve body.

D. Codes and Standards:

1. MSS Compliance: Mark valves in accordance with MSS-25 "Standard Marking System for Valves, Fittings, Flanges and Unions".
2. ANSI Compliance: For face-to-face and end-to-end dimensions of flanged- or welded-end valve bodies, comply with ANSI B16.10 "Face-to-Face and End-to-End Dimensions of Ferrous Valves".
3. U-PVC: Conforming to ASTM D1784 Cell Classification 12454 A
4. CPVC – Conforming to ASTM D1784 Cell Classification 23567 A
5. Polypropylene – Conforming to ASTM D4101 Cell Classification PP0210B67272
6. PVDF – Conforming to ASTM D3222-91A Cell Classification Type II

PART 2 - PRODUCT

2.1 PLASTIC BALL VALVES (1/2" – 6")

A. All valves shall be true-union design with 2-way blocking capability. PTFE seats shall have elastomeric backing cushions to provide smooth even stem torque and to compensate for wear. Valves shall feature molded ISO mounting top flange for actuation installation and Panel Mount feature on bottom of valve for securing in-line. The handle shall double as the spanner wrench for maintenance and carrier adjustment.

B. Valve shall have a pressure rating of 150 psi at 70ºF.

C. Where noted on contract drawings, a 1/8" Vent Hole factory drilled and de-burred by the manufacturer shall be added to eliminate the hazard of pressurization.

D. Acceptable Manufacturers: Subject to compliance with requirements, manufacturers offering ball valves which may be incorporated in the work are:

1. Asahi America, Inc.
2. George Fischer
3. Dura Plastic Products, Inc.
4. Hayward
5. Or equal.

2.2 STAINLESS STEEL BALL VALVES

A. Features:
1. 316 SS Ball Construction
2. SS Body construction
3. RPTFE seat
4. Threaded
5. Full Port
6. Two piece body design
7. Solid Ball Construction
8. SS Lever and Nut
9. Blow out proof stern design
10. Nylon lever grip
11. 150 psi rated

B. Acceptable Manufacturers: Subject to compliance with requirements, manufacturers offering ball valves which may be incorporated in the work are:
1. Apollo Valves
2. Or equal

PART 3 - EXECUTION

3.1 INSTALLATION:

A. General: Except as otherwise indicated, comply with the following requirements:

Install valves where required for proper operation of piping and equipment, including valves in branch lines where necessary to isolate sections of piping. Locate valves so as to be accessible and so that separate support can be provided when necessary.

Install valves with stems pointed up, in vertical position where possible, but in no case with stems pointed downward from horizontal plane.

B. Insulation: Where insulation is indicated, install extended-stem valves, arranged in proper manner to receive insulation.

C. Selection of Valve Ends (Pipe Connections): Except as otherwise indicated, select and install valves with the following ends or types of pipe/tube connections.

1. Pipe Size 2" and Smaller: One of the following, at Installer's option:

a. Threaded valves.
b. Flanged valves.

2. Pipe Size 2-1/2" and Larger:

a. Flanged valves.
b. Grooved joint valves.

D. Valve System: Select and install valves with outside screw and yoke stems, except provide inside screw non-rising stem valves where headroom prevents full opening of OS&Y valves.

E. Renewable Seats: Select and install valves with renewable seats, except where otherwise indicated.

3.2 ADJUSTING AND CLEANING:

A. Valve Adjustment: After piping systems have been tested and put into service, but before final testing, adjusting, and balancing, inspect each valve for possible leaks. Adjust or replace packing to stop leaks, replace valve if leak persists.

B. Valve Identification: Tag each valve in accordance with Division-22 section "Identification for Piping and Equipment".

3.3 VALVE INSTALLATION:

A. Locate all valves in locations which will allow easy operation and facilitates maintenance.

B. Provide chain operators for any valves located more than 8 feet above finished floor. This means double acting lever handles for quarter turn valves, or chain wheels for multi-turn valves. Arrange valves and set up chain length for proper operation.

END OF SECTION

SECTION 400572 - FLAP GATES

PART 1 - GENERAL CONDITIONS

1.1 SCOPE

A. This section covers fabricated Stainless Steel Circular Flap Gates.

1.2 GENERAL

A. The equipment provided under this section shall be fabricated, assembled, erected, and placed in proper operating condition in full conformity with the drawings, specifications, engineering data, instructions and recommendations of the equipment manufacturer, unless exceptions are noted by the engineer.

B. Flap Gates shall be supplied with all the necessary parts indicated on the drawings, specified or otherwise required for a complete, properly operating installation, and shall be the latest standard product of a manufacturer regularly engaged in the production of flap Gates.

C. Flap Gates supplied under this section shall be Series 39P Stainless Steel Flap Gates as manufactured by Golden Harvest or equal.

1.3 QUALITY ASSURANCE

A. The manufacturer shall have experience in the production of substantially similar equipment, and shall show evidence of satisfactory operation in at least 5 installations. The manufacturer's shop welds, welding procedures and welders shall be qualified and certified in accordance with the requirement of the latest edition of ASME, Section IX.

B. The manufacturer shall be ISO 9001: 2000 certified.

1.4 SUBMITTALS

A. The manufacturer shall submit, for approval by the purchaser, drawings showing the principal dimensions, general construction and materials used in the gate and lift mechanism.

PART 2 - PERFORMANCE

2.1 OPERATION

A. Flap Gates shall open whenever the upstream head is over 0.2’ (61mm) higher than the downstream head.

2.2 DESIGN HEAD

A. The Flap Gates shall be designed to withstand the design head shown in the schedule.

PART 3 - PRODUCTS

3.1 GENERAL DESIGN

A. Flap Gates shall be constructed entirely of stainless steel. All hardware shall be stainless steel.

3.2 WALL THIMBLE

A. The wall thimble shall be stainless steel and supplied by the gate manufacturer. Refer to the gate schedule for types and applicable locations. Material thicknesses shall be according to the manufacturer's recommendations.

3.3 BODY

A. The frame shall be made of structural members or formed plate welded to form a rigid one-piece frame. The frame shall be of the flange back design suitable for mounting to a standard flange.

3.4 COVER

A. The gate cover shall be made of structural members or formed plate adequately reinforced to withstand expected forces.

3.5 SEALS

A. Seals shall be made of resilient neoprene attached to the body by means of a retainer ring for flaps up to 24". Seals shall be made of EPDM attached to the frame with a stainless steel retainer for flaps over 24".

3.6 HINGES

A. Hinges shall consist of a stainless steel pin and shall have a UHMWPE bushing.

3.7 HINGE ARMS

A. Hinge arms shall be made of structural members or formed plates. Gates 30" (762 mm) and over in diameter shall have a 2-hinge arm arrangement, with 2 pivot joints per arm, an adjustable lower pivot with limited rotation and an adjustable upper hinge lug arrangement to permit adjustment of the gate opening sensitivity to unseating head

PART 4 - MATERIALS

Part	**Material**
Body, cover, hinges, hinge arm	Stainless steel ASTM A-240 Type 304L or 316L
Hinge bushing	Ultra high molecular weight polyethylene (UHMWPE) ASTM D-4020
Seal for flaps up to 24" (610 mm)	Neoprene ASTM D-2000 Grade 2 BC-510
Seal for flaps over 24" (610 mm)	EPDM ASTM D-2000
Fasteners	ASTM F593 and F594 GR1 for Type 304 and GR2 for type 316

PART 5 - EXECUTION

5.1 INSTALLATION

A. Gates and appurtenances shall be handled and installed in accordance with the manufacturer's recommendations.

END OF SECTION 400572

SECTION 400578 – COMBINATION RELIEF VALVES

PART 1 - GENERAL

1.1 SUMMARY

A. The Contractor shall provide plug valves and appurtenances, complete and operable, in accordance with the Contract Documents.

B. The requirements of Section 400557 - Valve and Gate Actuators apply to this Section.

C. Plug valves shall have undergone a proof-of-design test to demonstrate that the valve components operate at the service flow, pressure, temperature, and fluid conditions, free from binding, excessive noise, and premature failures. Proof-of-design test results shall be available to the Engineer on request. The proof-of-design test shall be conducted in accordance with the applicable provisions of AWWA C517.

1.2 CONTRACTOR SUBMITTALS

A. Furnish submittals in accordance with Section 013300.

PART 2 - PRODUCTS

2.1 GENERAL

A. This specification is intended to cover the design, manufacture, and testing of 1 in. through 8 in. combination air valves suitable for pressures up to 150 psig.

B. Combination air valves shall be automatic float operated valves designed to exhaust large quantities of air during the filling of a piping system and close upon liquid entry. The valve shall open during draining or if a negative pressure occurs. The valve shall also release accumulated air from a piping system while the system is in operation and under pressure. The valve shall perform the functions of both air release and air/vacuum valves and furnished as a single body or dual body type as indicated on the plans.

2.2 STANDARDS, APPROVALS AND VERIFICATION

A. Valves shall be manufactured and tested in accordance with American Water Works Association (AWWA) Standard C512.

B. Valves used in potable water service shall be certified to NSF/ANSI 61 Drinking Water System Components.

C. Manufacturer shall have a quality management system that is certified to ISO 9001 by an accredited, certifying body.

2.3 WASTEWATER COMBINATION VALVES

A. Connections

1. Single body valves sizes 4 in. and smaller shall have full size NPT inlets and outlets equal to the nominal valve size with a 2 in. inlet on 1 in. valves. The body inlet connections shall be hexagonal for a wrench connection. The body shall have 2" NPT cleanout and 1" NPT drain connection on the side of the casting.
2. Dual body valves sizes 3 in. and smaller shall have full size NPT inlets and outlets equal to the nominal valve size with a 2 in. inlet on 1 in. valves. The body inlet connection shall be hexagonal for a wrench connection. Valve sizes 4 in. through 6 in. shall have bolted flanged inlets and NPT outlets. 8 in. valves shall have flanged inlets and outlets. Flanges shall be in accordance with ANSI B16.1 for Class 125 iron flanges.
3. The valve shall have three additional NPT connections for the addition of backwash accessories.

B. Design:
1. Both single and dual body valves shall provide an extended body with a through flow area equal to the nominal size. Floats shall be unconditionally guaranteed against failure including pressure surges. A resilient bumper shall be provided on 4 in. and larger sizes to cushion the float during sudden opening conditions. The seat shall provide drop tight shut off to the full valve pressure rating.
2. Dual body valves shall consist of a wastewater air release valve piped to a wastewater air/vacuum valve with a full-ported brass ball valve.
   a. The wastewater air release valve shall have an extended leverage mechanism with sufficient mechanical advantage so that the valve will open under full operating pressure. An adjustable threaded resilient orifice button shall be used to seal the precision discharge orifice in the cover.
   b. The wastewater air/vacuum valve sizes 4 in. and larger shall have a cover fitted to the valve body by means of a machined register to maintain concentricity between the top and bottom guide bushings at all times. The tandem float assembly shall have a hexagonal guide shaft supported in the body by circular bushings to prevent binding from debris. The upper float shall be protected against direct water impact by an internal baffle. The seat shall be a minimum of 0.5 in. thick on 2 in. and larger valves and secured in such a manner as to prevent distortion.
3. Single body valves shall have a full port orifice, a double guided plug, and an adjustable threaded orifice button. The 1 in. body shall be globe style to increase float clearance and reduce clogging. The plug shall be protected against direct water impact by an internal baffle and an extended float stem. The plug shall have a precision orifice drilled through the center stem. The float shall include a sensitivity skirt to minimize spillage.

C. Materials:
1. The valve body and cover shall be constructed of ASTM A126 Class B cast iron.
2. The float, plug, guide shafts, and bushings shall be constructed of type 316 stainless steel. Non-metallic guides and bushings are not acceptable. Resilient seats shall be Buna-N.

2.4 WATER COMBINATION VALVES

A. Connections:
1. Dual body valve sizes 3 inches and smaller and single body valve sizes 4 inches and smaller shall have full size NPT inlets and outlets equal to the nominal valve size. The body inlet connection shall be hexagonal for a wrench connection.
2. Larger sizes shall have bolted flanged inlets and threaded or flanged outlets. Inlet flanges shall be in accordance with ANSI B16.1 for Class 125 or Class 250 iron flanges and ANSI B16.5 for Class 400 steel flanges.

3. The valve shall have two additional NPT connections for connection to gauges, testing and drainage.

B. Design

1. Both single and dual body valves shall provide a through flow area equal to the nominal size. Floats shall be unconditionally guaranteed against failure including pressure surges. The cover shall be bolted to the body and sealed with a flat gasket. A resilient bumper shall be provided on 4 in. (100 mm) and larger sizes to cushion the float during sudden opening conditions. The resilient seat shall be replaceable and provide drop tight shut off to the full valve pressure rating.
2. Dual body combination valves shall consist of an Air Release Valve piped to an Air/Vacuum Valve with a quarter-turn, full-ported bronze ball valve on 4 in. and larger sizes.
   a. The Air Release Valve shall have a leverage mechanism with sufficient mechanical advantage so that the valve will open under full operating pressure. Simple lever designs shall consist of a single pivot arm and a resilient orifice button. Compound lever designs shall consist of two levers and an adjustable threaded resilient orifice button.
   b. The Air/Vacuum Valve sizes 4 in. (100 mm) and larger shall have a cover fitted to the valve body by means of a machined register to maintain concentricity between the top and bottom guide bushings at all times. The float shall be double guided with a guide shaft extending through the float to prevent any contact with the body. The float shall be protected against direct water impact by an internal baffle bolted to the cover or integrally cast in the body. The seat shall be a minimum of .5 in. (12 mm) thick on 2 in. (50 mm) and larger valves and secured in such a manner as to prevent distortion. Valves with working pressures above 500 psig (3450 kPa) shall have metal seats with synthetic seals.
3. Single body combination valves shall have an expanded outlet to provide full flow area around the guide mechanism. The valve shall have a double guided plug on 2 in. (50 mm) and larger sizes, and an adjustable threaded orifice button. The plug shall be protected against direct water impact by an internal baffle. On valve sizes 4 in. (100mm) and smaller, the plug shall have a precision orifice drilled through the center stem. On valve sizes 6 in. (150 mm) and larger, air release and air/vacuum mechanisms shall be provided as separate units contained within the same body and meet the same design specifications for the Dual Body Combination Valve in section 3.2 above.
4. Floats shall be unconditionally guaranteed against failure including pressure surges. Extended mechanical linkage shall provide suitable mechanical advantage so that the valve will open under full operating pressure.

C. Materials

1. The valve body and cover shall be constructed of ASTM A126 Class B cast iron for Class 125 and Class 250 valves. Class 300 ductile iron valves shall be constructed of ASTM A536 Grade 65-45-12 ductile iron. Dual Body Class 300 steel valves shall be constructed of ASTM A216 Grade WCB cast steel.
2. The float, guide shafts, and bushings shall be constructed of Type 316 stainless steel. Non-metallic floats, linkage, or bushings are not acceptable. Resilient seats shall be Buna-N. Class 300 steel dual body valves shall have a 316 stainless steel seat with Buna-N seal to provide an initial contact to Buna-N with a final metal-to-metal contact to prevent over compression of the resilient seal.

D. Options

1. Low durometer seat and orifice button shall be furnished for low pressure applications.

2.5 MANUFACTURE

A. The manufacturer shall demonstrate a minimum of (5) years' experience in the manufacture of wastewater air valves. The valves shall be manufactured and tested in accordance with American Water Works Association standard (AWWA) C512. When requested, the manufacturer shall provide test certificates, dimensional drawings, parts list drawings, and operation and maintenance manuals.

B. The exterior of the valve shall be coated with a universal alkyd primer.

C. Acceptable Manufacturers:
   1. Valmatic
   2. Or Equal

PART 3 - EXECUTION

3.1 INSTALLATION

A. Except as otherwise indicated, comply with the following requirements:
   1. Install valves where required for proper operation of piping and equipment, including valves in branch lines where necessary to isolate sections of piping. Locate valves so as to be accessible and so that separate support can be provided when necessary.
   2. Install valves with stems pointed up, in vertical position where possible, but in no case with stems pointed downward from horizontal plane.

B. Insulation: Where insulation is indicated, install extended-stem valves, arranged in proper manner to receive insulation.

C. Valve System: Select and install valves with outside screw and yoke stems, except provide inside screw non-rising stem valves where headroom prevents full opening of OS&Y valves.

D. Renewable Seats: Select and install valves with renewable seats, except where otherwise indicated.

E. Locate all valves in locations which will allow easy operation and facilitates maintenance.

F. Provide chain operators for any valves located more than 8 feet above finished floor. This means double acting lever handles for quarter turn valves, or chain wheels for multi-turn valves. Arrange valves and set up chain length for proper operation.

3.2 ADJUSTING AND CLEANING:

A. Valve Adjustment: After piping systems have been tested and put into service, but before final testing, adjusting, and balancing, inspect each valve for possible leaks. Adjust or replace packing to stop leaks, replace valve if leak persists.

B. Valve Identification: Tag each valve in accordance with Division-22 section "Identification for Piping and Equipment".

3.3 MANUFACTURER'S CUSTOMER SERVICE

A. Manufacturer's authorized representative shall be available for customer service during installation and start-up, and to train personnel in the operation, maintenance and troubleshooting of the valve.

B. Manufacturer shall also make customer service available directly from the factory in addition to authorized representatives for assistance during installation and start-up, and to train personnel in the operation, maintenance and troubleshooting of the valve.

END OF SECTION

SECTION 409000 – INSTRUMENTATION AND CONTROL FOR PROCESS SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following:

1. General requirements which apply to all Instrumentation and Control for Process Systems (hereafter referred to as I&C).

B. Related Sections

1. The Contract Documents are a single integrated document. As such, all Divisions and Sections are applicable. The Contractor and its Subcontractors are responsible to review all parts of the Contract Documents in order to provide a complete and coordinated project.

C. Complete I&C System

1. The requirements for the I&C System shall be the responsibility of a single company hereafter referred to as the Instrumentation Supplier (IS). The IS shall be responsible for all parts of this Section and Sub-Sections as well as all other related sections that may pertain to the I&C System.
2. The Contractor, through the IS and qualified electrical and mechanical installers, shall be responsible to the Owner for the implementation of a complete I&C System. The IS shall provide all necessary coordination, material and labor such that the entire system be complete and functional. This includes but is not limited to the proper operation and monitoring of electrical power systems, process systems, mechanical equipment, instrumentation, control panels, programmable controllers, communications/networking, and SCADA system.
3. The overall I&C system design is based upon non-certified information that has been furnished by various equipment manufacturers and vendors. It is the Contractor's responsibility to include in the bid and installation all labor and material to provide a complete system based upon actual information from equipment being supplied for the project. Any changes or additions due to non-certified manufacturer or vendor information shall be provided at no additional cost to the Owner.

1.2 REFERENCES

A. The installation and commissioning of the I&C System shall conform to all applicable codes, regulations, standards and specifications, including, but not limited to those listed below. These publications are referenced to by designation but not by edition. The latest edition accepted by the Authority Having Jurisdiction in effect at the time of bid shall govern.

1. State and Local Codes and Authority Having Jurisdiction (AHJ)
2. American National Standards Institute (ANSI)

3. American Petroleum Institute (API)
4. Federal Communications Commission (FCC)
5. Federal Occupational Safety and Health Act (OSHA)
6. International Society of Automation (ISA)
7. Institute of Electrical and Electronic Engineers (IEEE)
8. National Electric Code (NEC).
9. National Electrical Manufacturers Association (NEMA)
10. National Fire Protection Association (NFPA)
11. Underwriters Laboratories, Inc. (UL)

1.3 DEFINITIONS

A. The following definitions may be used throughout this section and subsections (refer to the contract drawings sheet GI-1 for instrumentation abbreviations):

1. CTC: Communications termination cabinet.
2. FAT: Factory acceptance test.
3. HMI: Human machine interface.
4. I&C: Instrumentation and control for process systems
5. IS: Instrumentation supplier.
6. LAN: Local area network.
7. LCP: Local control panel.
8. NC: Normally closed.
9. NO: Normally open.
10. OIT: Operator interface terminal.
11. OSI: Owner's System Integrator.
12. PC: Personal computer.
13. PID: Control action, proportional plus integral plus derivative.
14. PLC: Programmable logic controller.
15. P&ID: Process and instrumentation diagram
16. RIO: Remote input/output
17. SCADA: Supervisory control and data acquisition.
18. UPS: Uninterruptible power supply.
19. VCP: Vendor control panel.
20. WAN: Wide area network

1.4 I&C SYSTEM REQUIREMENTS

A. Work provided outside of Contractor's scope:
   1. All PLC and HMI equipment being supplied by the Contractor is to be programmed by the Owner's System Integrator except for PLC and HMI equipment that is furnished by Vendors.

B. The Work is to provide a complete and operational I&C System as described by the Contract Documents. This includes but is not limited to the following:

   1. Before providing a bid as the IS, coordinate with all bidders such that all costs associated with a complete I&C System are accounted for. The Owner shall not be responsible for

any additional costs for scope items that have been excluded from the bid as a result of not coordinating with all bidders.

2. The IS shall submit a statement of qualifications verifying that it meets the requirements of 409000.1.8. The IS must be approved by the Engineer before proceeding with the Work.

3. In order to provide a complete system, oversee and coordinate with all equipment and services being provided outside of Contractor's scope.
   a. The Engineer is responsible to ensure that equipment being supplied by the Owner related to the I&C System complies with the requirements of the Contract Documents.
   b. The Contractor and IS are responsible to coordinate the installation, commissioning and scheduling of equipment related to the I&C System that are provided by the Owner.

4. Oversee and coordinate with all equipment and services being provided by the Contractor but outside of the IS's scope.
   a. Inform all vendors and suppliers providing equipment related to the I&C System the requirements of Division 40.
   b. The Owner is not responsible for any additional costs incurred by requiring vendors and/or subcontractors to meet the requirements of Division 40.
   c. If a vendor or supplier is unable to meet the requirements of Division 40, the Contractor may submit in writing to the Engineer the reasons for non-compliance. The Engineer will then evaluate the reasons and determine whether a solution may be determined or if a different vendor or supplier is required.
   d. The Contractor and IS are responsible for coordinating with vendors and suppliers the FAT, installation, commissioning, calibration and scheduling for the associated I&C equipment.
   e. The IS is responsible to insure that panel and loop drawings be supplied for vendor and subcontractor equipment. If the vendors and/or subcontractors are preparing the panel and/or loop drawings, they shall comply with the requirements of Division 40 and shall match those provided by the IS.

5. The IS shall conduct a Pre-Submittal Conference before producing any submittals. The conference should include all parties involved with the I&C System including the Engineer and Owner. The purpose of the conference shall be to review the project as a whole, make sure all parties understand their roles and responsibilities and to go over submittal requirements.

6. Prepare I&C System Submittals which includes the following:
   a. Instrumentation hardware submittal (including TR20 forms).
   b. Control panels design and submittal.
   c. Loop drawings design and submittal.
   d. Recommended spare parts submittal.

7. Following submittal approvals, do the following:
   a. Procure all instrumentation hardware and accessories.
   b. Procure hardware for and fabricate all control panels being provided.
   c. Perform FAT's for all control panels being provided.

8. Loop drawings design and submittal shall be supplied by the OSI. The IS shall assist the OSI in obtaining all pertinent information for the project that is to be shown on the loop drawings.

9. Programming and integration shall be supplied by the OSI. Oversee and coordinate the programming and integration with the OSI for a complete I&C System.

10. Oversee the installation of the I&C System.

11. Perform bench and field calibrations of instruments as required.

12. Oversee and document loop testing.

13. Oversee and document commissioning.

14. Maintain record drawings.
    a. Maintain on the construction site a set of the Instrumentation Drawings that shall be continuously marked up during construction.
    b. The drawings should be updated at least weekly and will be checked monthly by the Owner's representative.
    c. Upon completion of startup, submit the marked-up drawings to the Engineer for review and for drafting.

15. Prepare O&M manuals.
    a. Provide O&M manuals in accordance with Section 017823.
    b. Prepare an O&M manual for each major process area or building. Each of these manuals shall be divided into the following categories:
        1) Table of Contents/Index.
        2) Process & Instrumentation Diagrams
        3) Control Panel Record Drawings, Bill of Materials and Design Data.
        4) Record Loop Drawings
    c. Prepare O&M manuals that cover comprehensive information for the I&C System. These manuals shall include the following:
        1) Table of Contents/Index.
        2) Finalized Instrument Summary
        3) Finalized TR20 Instrument Forms
        4) Instrumentation Installation Details
        5) Instrument Operational Manuals
        6) Recommended Spare Parts List

16. Provide training.

1.5 ACTION SUBMITTALS

A. General
1. Submittals for Division 40 shall meet the requirements of Section 013300 Contractor Submittals. In addition, the following requirements shall be met:
    a. Submittals shall include bills of materials with quantities, makes, models, exact part numbers and descriptions.

b. Edit all submittals such that only pertinent information is submitted. Neatly cross out information that does not apply, options that are not being supplied, etc.
c. Show product dimensions, construction and installation details, wiring diagrams, and specifications.
d. If there are exceptions to the Contract Drawings and Specifications, provide a list of exceptions with detailed explanations for the exceptions. The Engineer will review the list of exceptions and determine whether a solution may be determined or if the exception(s) will not be allowed.
2. Furnish submittal required by each Section within Division 40.
3. When submitting on equipment, use the equipment and instrumentation tags depicted in the Contract Drawings.

B. Instrumentation hardware submittal
1. Provide a comprehensive submittal that includes all instrumentation being supplied by the IS. Divide the submittal into the following:
a. Table of Contents/Index.
b. Instrument summary.
c. Instrument TR20 Forms.
d. Instrument Cut Sheets.
e. Instrument Installation Drawings.
2. Provide an instrument summary (sorted by tag number) that has the following information:
a. Tag number.
b. Make, model and description.
c. Associated process.
d. Location.
e. Calibrated range.
f. Referenced loop drawing number and P&ID.
g. Associated PLC.
3. Furnish TR20 instrumentation forms for each instrument using the forms outlined in ISA-TR20.00.01-2007. This requirement includes all instruments that are being installed as part of the project, whether they are Contractor, Owner and/or Vendor supplied. Show on each sheet who is the responsible party for supplying the instrument. The TR20 sheets should be provided electronically in Microsoft Word or Excel as well.
4. Provide instrument cut sheets for each instrument make and model being supplied for the project. Each cut sheet should have a list of instrument tag numbers that pertain to that particular cut sheet. The cut sheets should have enough information to verify that the instrument conforms to the Contract Drawings and Specifications.
5. Instrument installation drawings
a. Provide instrument installation drawings for each make and model of instrument being supplied.
b. Delineate what is being supplied by the IS and what is being supplied by other installers.
c. Show overall dimensions, mounting locations and elevations.
d. Show all cabling, conduit and piping locations.
e. Show the ambient conditions of the location where the instrument is being installed which includes ambient temperature and humidity extremes, whether or not the atmosphere is corrosive and the area classification.
f. Show mounting requirements, brackets, stands and anchoring.
g. Show means for sun protection where required.

C. Control panels submittal

1. Provide a comprehensive submittal that includes all control panels supplied by the IS. The submittal should show that the panels are in conformance with the requirements of Section 409513. Divide the submittal into the following:
   a. Table of Contents/Index.
   b. Panel Bill of Materials and Design Data.
   c. Panel Shop Drawings.
   d. Panel Hardware Cut Sheets.
2. The Panel Bill of Materials and Design Data shall include the following:
   a. Each panel will have its own Bill of Materials and Design Data information presented in association with the panel drawings. The Bill of Materials shall include all hardware inside or on the enclosure. The design data will include UPS and/or battery load calculations to show that the UPS is sized appropriately for load and for backup time. The design data will show panel weight, materials and finishes. HVAC design data shall be shown. Seismic criteria shall be shown if required by the Contract Documents.
3. Panel Shop Drawings:
   a. Each control panel shall be designed to perform its function(s) as shown in the Contract Drawings. The control panel designs shall take into account information shown throughout the Contract Drawings and Specifications.
   b. Show every internal wire and connection diagrammatically. Show all interfaces between the control panel and external equipment to be connected for power, controls, signal, communications, etc.
   c. All shop drawings shall include a title block with the name of the firm designing the control panels. The title block shall also include project information, Owner information and/or logo, drawing number and description, revision fields and date.
   d. All shop drawings shall be developed utilizing AutoCAD version 2008 or later. All shop drawings should be submitted in PDF and AutoCAD formats and as required by Section 013300.
   e. Panel layout drawing(s):
      1) Each control panel shall have shop drawing(s) which depict the front, back, sides and top/bottom of the panel. This includes showing any hardware mounted on the inside or outside of the panel.
      2) Layout drawings should include subpanel and swing-out panel layouts.
      3) Layout drawings should show locations of panel penetrations for cutouts, conduit entry and/or access plates.
      4) Layout drawings should show all of the components and provide a reference to the bill of materials.
      5) Show the elevations of door devices from the finished floor.
   f. AC and/or DC power distribution diagrams:
      1) Each panel shall show power distribution schematics that shows how the panel receives power and feeds all of its internal loads as well as associated external loads.
   g. Communications and/or Network diagrams:
      1) For panels that utilize any means of communications both internally and externally, provide a diagram depicting each communication connection.
   h. Input/Output and/or Internal wiring diagrams
   i. Terminal block diagrams
4. Provide panel hardware cut sheets for each make and model of equipment being supplied for the project. The cut sheets should have enough information to verify that the equipment conforms to the Contract Drawings and Specifications.

D. Loop Drawings Submittal

1. Provide a comprehensive submittal that includes loop drawings for every control loop on the project. This includes but is not limited to all loops shown on the P&ID's, all loops associated with auxiliary inputs/outputs not shown on the P&ID's (e.g. UPS status information).
2. Loop drawings may only be finalized after all control panels, MCC's and other electrical submittals, and instrumentation submittals have been approved. Obtain all of the required information from each of these submittals to properly show the wiring of each control loop. The loop drawings shall not be submitted with incomplete information due to the lack of obtaining the appropriate information for each loop.
3. The loop drawings shall designed for and printed to 11x17 size paper. Divide the submittal into the following:
    a. Laminated Cover and Back and Spiral Binding.
    b. Table of Contents/Index (by loop number).
    c. Loop Drawings.
4. Loop Drawings Requirements:
    a. All loop drawings shall include a title block with the name of the firm designing the loop drawings. The title block shall also include project information, Owner information and/or logo, drawing number and description, revision fields and date.
    b. All loop drawings shall be developed utilizing AutoCAD version 2008 or later. All loop drawings should be submitted in PDF and AutoCAD formats and as required by Section 013300.
    c. Each loop drawing shall have a look and feel that follows that of the example loop drawing shown in the Contract Drawings.
    d. Each loop drawing should have the following as a minimum:
        1) Six area divisions, from left to right which are:
            a) Field/Process Area (this area will show field and process equipment).
            b) Junction Boxes (this area will show any field junction boxes associated with the loop).
            c) Local Control Panel (this area will show any local control panels associated with the loop).
            d) Electrical Room (this area will show electrical equipment such as starters, VFD's, power feeders, etc. associated with the loop).
            e) Programmable Logic Controller (this area will show PLC Inputs/Outputs associated with the loop).
            f) SCADA (this area will show logical connections for the Inputs/Outputs from the PLC to the SCADA System).
    e. Each loop drawing will show each instrument or field device associated with the loop and its wiring connections and wire labels.
    f. Each electrical enclosure (junction box, local control panel, PLC panel, starter panel, etc.) will show terminal numbers and terminal block group references.
    g. All wires to be installed by the Contractor shall be dashed while all wires installed by the panel shop should be solid.
    h. Show continuation lines to associated loops that may interface with each loop.
    i. Show all wiring associated for the loop including power, controls, signal and communications.

E. Recommended Spare Parts Submittal

1. Submit a list of spare parts for all of the equipment associated with the I&C System. The list of spare parts shall include list pricing for each item.

2. Provide the name, address and phone number for each manufacturer and manufacturer's local sales representative.
3. Indicate whether or not the spare parts are being provided under this contract or not.

1.6 INFORMATIONAL SUBMITTALS

A. Field quality-control test reports.

1.7 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.8 QUALITY ASSURANCE

A. All equipment supplied for this project shall meet the requirements of the National Electric Code (NEC) and shall be listed by and bearing the label of the Underwriters' Laboritories (UL).

B. The IS shall be a company that has been actively involved in the installation and commissioning of I&C Systems for a minimum period of five years.

C. The IS shall have adequate facilities, manpower and technical expertise to perform the Work associated with the I&C System and as outlined by the Contract Documents.

D. The IS shall have similar project experience of at least four successfully completed projects for a similar wastewater system. The IS company must have performed similar work for these projects as required herein.

PART 2 - PRODUCTS

2.1 MATERIALS

A. All materials provided under this Contract shall be new and free from defects.

2.2 MANUFACTURERS

A. All equipment provided for the I&C System 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.

B. Instruments which utilize a common measurement principle (for example, float switches) 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.

2.3 OPERATING CONDITIONS

A. The I&C System shall be designed and constructed for satisfactory operation and long, low maintenance service under the following conditions:
   1. Environment: Type the type of facility this is for such as “Wastewater Treatment Plant”.
   2. Temperature Extremes: 30°F to 120°F (Outdoors); 40°F to 104°F (Indoors).
   3. Relative Humidity: 20% to 90%, non-condensing.

B. 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 20 percent within the minimums and maximums of their rated environmental operating ranges. The Contractor shall provide power wiring for these devices. Enclosures suitable for the environment shall be furnished. Instrumentation in hazardous areas shall be suitable for use in the particular hazardous or classified location in which it is to be installed.

2.4 SPECIAL TOOLS

A. The IS shall furnish a priced list of special tools required to calibrate and maintain the instrumentation provided. The Owner and Engineer will select which tools are to be purchased and the IS will supply them at the prices listed.

B. Special tools shall be delivered to the Owner before startup commences.

PART 3 - EXECUTION

3.1 DELIVERY, STORAGE AND HANDLING

A. After completion of shop assembly, factory test, and approval, equipment, cabinets, panels, and consoles 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 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. Each component shall be tagged to identify its location, instrument tag number, and function in the system. A permanent stainless steel or other non-corrosive material tag firmly attached and permanently and indelibly marked with the instrument tag number, as given in the tabulation, shall be provided on each piece of equipment in the PCIS. Identification shall be prominently displayed on the outside of the package.

D. Equipment shall not be stored outdoors. Equipment shall be stored in dry permanent shelters, including in-line equipment, and shall be adequately protected against mechanical injury. If any apparatus has been damaged, such damage shall be repaired by the Contractor. If any apparatus has been subject to possible injury 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 MANUFACTURER’S SERVICES

A. Manufacturer’s services shall be furnished for the following equipment:
   1. Vendor supplied equipment that contain programmable controllers, operator interfaces and/or instrumentation that requires site calibration.
   2. pH Analyzers
   3. ORP Analyzers
   4. Ammonia Analyzers
   5. TSS Analyzers
   6. Dissolved Oxygen Analyzers
   7. Open Channel Flow Meters
   8. Mass Flow Meters
   9. Turbidity Analyzers
   10. Gas Detectors

B. The Contractor shall furnish the following manufacturer's services for the instrumentation listed below:
   1. Perform bench calibration.
   2. Oversee installation.
   3. Verify installation of installed instruments.
   4. Certify installation and reconfirm manufacturer's accuracy statement.
   5. Oversee loop testing and pre-commissioning
   6. Train the Owner's personnel.

3.3 INSTALLATION

A. Instrumentation shall be installed per the Instrument Installation Drawings that have been submitted and approved and per the requirements of Division 40. This includes all instrumentation for the I&C System, regardless of who the supplier is. Instrumentation shall be mounted so that it is easily accessible and viewable and such that it does not restrict access to other equipment. Mount instrumentation to pipe stands or wall mounts if they are not directly mounted or if the Contract Drawings indicate otherwise.

B. The I&C System indicated throughout the design are diagrammatic and therefore locations of equipment are approximate. 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.

C. The I&C System is integrally connected to electrical, mechanical and structural systems. Coordinate with these other disciplines the installation of these related components. All conduit, cables and field wiring shall be as required by Division 26.

D. Instruments, control panels and all other I&C System related equipment shall be anchored by methods that comply with seismic requirements applicable to the Site.

E. Each existing instrument 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.

F. The Contract Documents show necessary conduit and instruments required to make a complete instrumentation system. 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.

G. Instrumentation, control panels, wiring and all other I&C equipment shall be properly tagged and/or labeled per the requirements of Section 260553.

H. Installation of the I&C System shall be according to the finalized Loop Drawings

3.4 FACTORY ACCEPTANCE TESTING (FAT)

A. The IS shall arrange for the manufacturers of the equipment and fabricators of panels and cabinets supplied under this Section to allow the Engineer and Owner to inspect and witness the testing of the equipment at the site of fabrication. Equipment shall include the cabinets, special control systems, and other pertinent systems and devices. A minimum of 10 days notification shall be furnished to the Engineer prior to testing. No shipments shall be made without the Engineer's approval.

B. For each FAT, the IS shall develop and submit a FAT Plan and Procedure Document within 10 days of the FAT. The FAT Plan and Procedure shall as a minimum shall have the following:
1. Descriptions of test methods to be performed during the FAT.
2. FAT Schedule and Procedure
3. FAT Checklists that allow for sign-off and comments for each test method and procedure.

C. Control Panel Completion Test Methods: The following test methods should be performed during the FAT for each control panel:
1. Completed Shop Drawings: Demonstrate that the control panel has been built according to the shop drawings and that the shop drawings are accurate.
2. Panel Layout: Demonstrate that the control panel has been laid out as designed and as required by Division 40.
3. Power Distribution: Demonstrate all power distribution circuits, including but not limited to AC power circuits, UPS operation, signals and circuits and DC circuits.
4. Control Circuits: Demonstrate the correct installation of each control circuit. Using a signal generator or multi-meter, show the correct operation of each input, output, relay, barrier, buttons, switches, or any other control device. Demonstrate the proper

functionality of any hard-wired interlocks that may be associated with each control circuit.

5. Panel Networking/Communications: If any form of communications is associated with the control panel, verify the proper operation of each communication port and link.

D. Control Loop Test Methods: In order to demonstrate that the control panel will provide its function as intended, provide the following control loop test methods. If programming for the control panel is provided by others, coordinate with the programmer to have all programming completed and tested prior to the FAT. If needed, coordinate to have the programmer present for the FAT.

1. Alarm Functions: Verify and/or simulate each alarm condition associated with each control loop.
2. Local Manual and Auto Functions: Verify and/or simulate each Local Manual and/or Auto function associated with each control loop.
3. SCADA Manual and Auto Functions: Verify and/or simulate each SCADA Manual and/or Auto function associated with each control loop.
4. Control Loop Interlocks: Demonstrate the functionality of any software interlocks that may be associated with each control loop.

E. If the FAT does not pass and needs to be repeated, the IS shall be responsible for additional per diem costs incurred by the Engineer and Owner.

F. All changes and/or corrections made during the FAT shall be noted on the checklists.

G. Following completion and approval of all FAT, provide the finalized checklists to the Engineer and as part of the equipment shop drawings.

3.5 FIELD QUALITY CONTROL

A. Allow for inspections by the Engineer and/or Owner of the I&C System at any time during the construction. Inspections shall be conducted to verify that the installation is per the requirements of the Contract Documents.

3.6 CALIBRATION

A. Devices provided under Division 40 shall be calibrated according to the manufacturer's recommended procedures to verify operational readiness and ability to meet the indicated functional and tolerance requirements.

B. Each instrument shall be calibrated at 0, 25, 50, 75, and 100 percent of span using test instruments to simulate inputs. The test instruments shall have accuracies traceable to National Institute of Standards and Testing.

C. Instruments that have been bench-calibrated shall be examined in the field to determine whether any of the calibrations are in need of adjustment. Such adjustments, if required, shall be made only after consultation with the Engineer.

D. 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. 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. For each instrument calibration, provide a calibration sheet and update the corresponding TR20 Instrument Form with the new calibration data. The Calibration sheet shall include the following as a minimum:

1. Date of calibration
2. Project Name.
3. Tag Number.
4. Manufacturer, model and serial number.
5. Calibration data including range, input, output and measurement at each calibration point.
6. Space for comments.
7. Space for sign-off by party performing calibration.

G. A calibration and testing tag shall be attached to each piece of equipment or system at a location determined by the Engineer. The IS shall sign the tag when calibration is complete. The Engineer will sign the tag when the calibration and testing has been accepted.

3.7 LOOP TESTING

A. Each control loop shall have been installed according to the finalized loop drawing. Prior to the commencement of loop testing, the following pre-requisites should have been met:

1. All associated equipment, conduit and wire has been permanently installed, terminated and inspected.
2. All wiring has been properly pulled, terminated and labeled.
3. Each wire has been tested with a point-to-point test.
4. All control panels and electrical equipment have been checked out and tested as required by Division 26.
5. All instrumentation has been appropriately installed and calibrated.
6. Loop Test Forms for each loop to be tested have been created and will be available during the loop testing.

B. Each loop test shall have a Loop Test Form prepared and ready prior to each loop test. The loop test form shall have the following:

1. Loop Number and Description
2. Check-Off List with room for sign-off and dated by the IS, Programmer, and Owner's Witness as well as room for comments. The list of items to be checked off for each loop should include but is not limited to the following:
   a. Each power distribution circuit.
   b. Each control circuit.
   c. Each alarm circuit.
   d. Each PLC input/output point.
   e. Each Local Manual, Local Auto, SCADA Manual & SCADA Auto function.
   f. Each hard-wired and software interlock.

C. Upon completion of the above pre-requisites for loop testing, the IS shall oversee and coordinate each loop test. The IS is responsible to be present for all loop testing, whether the equipment was supplied by the IS or not. The IS is responsible to have all responsible parties associated with each loop present. This includes but is not limited to manufacturer representatives, vendor technicians, electrical installers, mechanical installers, and programmer. The IS shall coordinate with the Owner and Engineer to allow for witnessing of loop testing as deemed necessary by the Owner and Engineer.

D. Issues that arise during loop testing should be addressed and fixed immediately. If it is not feasible to immediately fix the issues, the loop testing should be re-scheduled as soon as possible to avoid delays. Any costs associated with re-testing and requiring all parties to return to the site shall in no way be incurred to the Owner.

E. Following a successful loop test, the appropriate parties should sign and date the Loop Test Forms. All Forms shall be certified and submitted to the Engineer as part of the O&M Manuals.

F. Following loop testing, in no way should any parts of the loop be modified. In no way shall any wiring be re-routed or re-terminated. If any such work occurs, all affected loops shall be re-tested at no expense to the Owner.

3.8 COMMISSIONING

A. The IS shall oversee, coordinate and be present during all commissioning activities. The IS shall be responsible for obtaining the assistance of the Contractor and Subcontractors as may be required for commissioning activities.

B. Commissioning shall commence after acceptance of wire test, calibration tests and loop tests, and inspections have demonstrated that the instrumentation and control system complies with Contract requirements. Pre-commissioning shall demonstrate proper operation of every system with process equipment operating over full operating ranges under conditions as closely resembling actual operating conditions as possible.

C. 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 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 commissioning and test requirements have been satisfied.

D. Where feasible, system commissioning activities shall include the use of water 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, 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. 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 field mounted automatic analog controllers or software based 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 field mounted, and software-based automatic analog 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.

E. Electronic control stations incorporating proportional, integral or differential 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 setpoint 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.

3.9 TRAINING

A. Develop a Training Plan for the training requirements of Division 40 and submit it to the Engineer for approval. Coordinate with the Engineer and Owner the time and locations of each training session. Schedule the trainings for after the equipment has been pre-commissioned.

B. As part of the Training Plan, submit a résumé for each individual to be providing training. Training shall be performed by qualified representatives of the equipment manufacturers and shall be specific to each piece of equipment.

C. Each training session shall include a written agenda.

D. The Contractor shall train the Owner's personnel on the maintenance, calibration and repair of instruments provided.

E. Within 10 days after the completion of each session, the Contractor shall submit the following:
   1. A list of Owner personnel who attended the training.
   2. A copy of the training materials used during the session with notes, diagrams and comments.

END OF SECTION 409000

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SECTION 409116 – ELECTROMAGNETIC PROCESS MEASUREMENT DEVICES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Conductivity Process Measurement Devices.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product indicated.

B. Instrumentation TR20 forms.

1.3 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

1.4 QUALITY ASSURANCE

A. Equipment to be furnished under this section shall be the product of firms regularly engaged in the design and manufacturing of this type of equipment. Manufacturer shall assume responsibility for, and guarantee performance of equipment furnished. However, this shall not be construed as relieving the Contractor from responsibility for the proper installation and functionality of the work.

B. Examine the Contract Documents and verify that instruments being provided are compatible with the physical and process conditions associated with the instrument. This includes compatibility with liquids, gases, pressures, temperatures, flows, materials, locations and mounting requirements. Provide all necessary accessories to the instrument for a complete and operable system.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Deliver the process measurement equipment as a complete system. Each system shall be properly tagged and identified with its corresponding instrument tag as shown on the P&ID's. Each system shall be factory calibrated and certified prior to delivery.

PART 2 - PRODUCTS

2.1 GENERAL

A. Each process measurement system shall consist of a sensor and an analyzer/transmitter. Where shown on the drawings, the analyzer/transmitter may be utilized for multiple sensors. When an analyzer/transmitter is used for multiple sensors, it shall be capable of displaying simultaneously each process measurement.

B. Each analyzer/transmitter shall be equipped with means to transmit process measurement information to the plant SCADA system.

   1. For hardwired signals, unless otherwise indicated on the drawings, provide the following:
      a. 4-20mA output signal for each process measurement (for up to 500 Ohm loads)
      b. Two programmable SPDT relay outputs, rated at 5A up to 230VAC, for each process measurement

C. Each analyzer/transmitter shall be powered by 115VAC (+/- 10%) at 60Hz unless specifically shown on the drawings as being powered by 24VDC (+/- 15%). Each analyzer/transmitter shall retain its programmable settings in non-volatile memory.

D. Each sensor and corresponding analyzer/transmitter shall be supplied as a complete and operable system. This includes all cabling, mounting hardware and fasteners. When installed outdoors, the analyzer/transmitter shall be protected from the sun such that direct sunlight will not shine on the display.

E. All analyzers/transmitters shall be waterproof and made from corrosion resistant materials.

F. All sensors shall be rated for permanent submersion and shall be corrosion resistant.

2.2 CONDUCTIVITY PROCESS MEASUREMENT DEVICES

A. Each Conductivity analyzer/transmitter shall be rated for operation with ambient temperature within -4°F to 122°F. If the analyzer/transmitter is to be installed in locations that may experience temperatures less than -4°F, it shall be housed in an enclosure which is equipped with a thermostatically controlled heater. If the analyzer/transmitter is to be installed in locations that may exceed 122°F, it shall be housed in an air conditioned enclosure. All enclosures and air conditioners shall be rated NEMA 4X.

B. The Conductivity Sensor assembly shall meet the following criteria:

   1. Contain the sensing elements and electronics for digital communications to the analyzer/transmitter in a self-contained, corrosion-resistant and submersible housing.
   2. The controller displays conductivity in mS/cm or µS/cm and temperature in Celsius or Fahrenheit.
   3. Built-in temperature compensation.
   4. Allowed to be installed in liquids whose temperatures are 32 to 200°F and whose pressure is up to 100 psi.

5. The sensor shall be selected based upon the normal conductivity range for the application and per the manufacturer's recommendation.
6. Shall not require sample conditioning or electrolyte solutions.

C. Acceptable Manufacturers:
1. Hach digital contacting Conductivity System with SC200 or SC1000 analyzer/transmitter.
2. WTW/Xylem model TetraCon 700 IQ Conductivity System with 182 or 2020 analyzer/transmitter.
3. Or Equal

PART 3 - EXECUTION

3.1 INSTALLATION

A. Equipment and materials specified in this section shall be installed, connected, and tested in accordance with the manufacturers' recommendations and as required by these specifications and contract drawings. Contractor shall coordinate with other trades to insure proper connection to piping and other mechanical equipment.

B. Install all analyzers/transmitters five feet off of floor level. Install in a location that is easily accessible while as near to the sensor(s) as possible.

3.2 CALIBRATION AND COMMISSIONING

A. A manufacturer representative shall field calibrate the process measurement system as required by section 409000 and per the manufacturer's documented calibration procedure. The system shall be calibrated to the proper ranges as required by the Owner and the Engineer. Where analog signals are connected to local or remote monitoring equipment, verify that the calibrated ranges and scaling of the local and remote indicators are correct.

B. Prior to final acceptance of the work, the Contractor shall certify the equipment and installation included under this section to be free of defects, and suitable for trouble-free operation.

3.3 FIELD QUALITY CONTROL

A. Tests and Inspections:

1. Visually inspect the installation of the process measurement systems. Verify that the incoming power is within the required range. Verify the functionality of all output signals and communications connections.

2. Test the process measurement system for proper operation at low, mid and high process conditions.

B. Document data for each measurement and for system calibration. Update the TR20 instrument forms following testing and calibration.

3.4 TRAINING

A. Provide a minimum of four hours of training for each type of process measurement system provided. Provide training in accordance with section 409000.

END OF SECTION 409116

SECTION 409119 – PHYSICAL PROPERTIES PROCESS MEASUREMENT DEVICES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Pressure Process Measurement Devices.
2. Temperature Process Measurement Devices.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product indicated.

B. Instrumentation TR20 forms.

1.3 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

1.4 QUALITY ASSURANCE

A. Equipment to be furnished under this section shall be the product of firms regularly engaged in the design and manufacturing of this type of equipment. Manufacturer shall assume responsibility for, and guarantee performance of equipment furnished. However, this shall not be construed as relieving the Contractor from responsibility for the proper installation and functionality of the work.

B. Examine the Contract Documents and verify that instruments being provided are compatible with the physical and process conditions associated with the instrument. This includes compatibility with liquids, gases, pressures, temperatures, flows, materials, locations and mounting requirements. Provide all necessary accessories to the instrument for a complete and operable system.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Deliver the process measurement equipment as a complete system. Each system shall be properly tagged and identified with its corresponding instrument tag as shown on the P&ID's. Each system shall be factory calibrated and certified prior to delivery.

PART 2 - PRODUCTS

2.1 GENERAL

A. Each process measurement system shall consist of a sensor and an analyzer/transmitter. Where shown on the drawings, the analyzer/transmitter may be utilized for multiple sensors. When an analyzer/transmitter is used for multiple sensors, it shall be capable of displaying simultaneously each process measurement.

B. Each analyzer/transmitter shall be equipped with means to transmit process measurement information to the plant SCADA system.

1. For hardwired signals, unless otherwise indicated on the drawings, provide the following:
    a. 4-20mA output signal for each process measurement (for up to 500 Ohm loads)
    b. Two programmable SPDT relay outputs, rated at 5A up to 230VAC, for each process measurement

2. Where shown on the drawings, provide the following digital communications to the plant SCADA system:
    a. Modbus RTU (Two-Wire RS-485)

C. Each analyzer/transmitter shall be powered by 115VAC (+/- 10%) at 60Hz unless specifically shown on the drawings as being powered by 24VDC (+/- 15%). Each analyzer/transmitter shall retain its programmable settings in non-volatile memory.

D. Each sensor and corresponding analyzer/transmitter shall be supplied as a complete and operable system. This includes all cabling, mounting hardware and fasteners. When installed outdoors, the analyzer/transmitter shall be protected from the sun such that direct sunlight will not shine on the display.

E. All analyzers/transmitters shall be waterproof and made from corrosion resistant materials.

F. All sensors shall be rated for permanent submersion and shall be corrosion resistant.

2.2 PRESSURE PROCESS MEASUREMENT DEVICES

A. General

1. All inline pressure instruments shall be supplied with isolation ball valve and bleed needle valve for each measurement point. Valve materials shall be selected based upon the properties of the liquid or gas and the atmosphere.

2. Unless otherwise indicated on the Contract Drawings, pressure process measurement devices shall measure process pressure relative to atmospheric pressure (gauge pressure).

3. Pressure process measurement devices which are to measure differential pressure shall have the appropriate inlet and outlet ports and isolation and bleed valves for each port.

4. All pressure instrumentation shall be properly mounted, ideally in locations that are easily accessible and viewable. Supply all appropriate mounting poles, plates and accessories such that each instrument is properly supported and mounted.

B. Inline Pressure Diaphragm Seals

1. Diaphragm seals shall consist of bottom housing, lower ring, diaphragm capsule, fill screw, flushing connection, and a top housing.

2. The diaphragm seal shall attach to the inlet connection of a pressure instrument to isolate its measuring element from the process fluid. The space between the diaphragm and the pressure element shall be completely filled with a suitable liquid. Displacement of the liquid fill in the pressure element through the movement of the diaphragm shall transmit process pressure changes directly to a gauge, transmitter, switch, or other pressure instrument. The diaphragm seal shall have a removable bottom housing to permit servicing. The diaphragm seal shall be factory assembled to the corresponding pressure instrument and be factory-filled. The assembly shall be shipped with a tag reading "Do not disassemble for installation."

3. For sewage, sludge, liquids containing solids, corrosive gases, provide seals with 316SS diaphragm and housing. Nuts, bolts, fill connection and valved flush components shall also be 316SS.

4. For chemical solutions and for liquids or gases that will corrode 316SS, provide seals with PVC body and Viton FKM (for vacuum and up to 15 PSI) or PTFE (for above 15 psi) diaphragm material.

5. Acceptable Manufacturers
   a. Ashcroft model 101 (for 316SS diaphragm seals).
   b. Plast-O-Matic Valves Inc. Series GGS (for PVC body diaphragm seals).
   c. Or Approved Equal.

C. Flanged Large Diaphragm Seals

1. Flanged type diaphragm seals shall be used where clogging and/or high accuracy is required. The flanged housing shall be constructed of 316SS.

2. The diaphragm seal shall consist of a flange with flush or extended diaphragm such that the diaphragm surface is flush with the walls of the pipe surface. It shall have a direct mount, coplanar, welded connection for connection of the pressure sensor to the seal.

3. The diaphragm seal shall attach to the inlet connection of a pressure instrument to isolate its measuring element from the process fluid. The space between the diaphragm and the pressure element shall be completely filled with a suitable liquid that is rated for the environmental conditions. Displacement of the liquid fill in the pressure element through the movement of the diaphragm shall transmit process pressure changes directly to a gauge, transmitter, switch, or other pressure instrument.

4. Acceptable Manufacturers
   a. Rosemount Series 1199.
   b. Or Approved Equal.

D. Annular Ring Diaphragm Seals

1. The pressure sensing ring shall measure pressure for 360 degrees around the full inside circumference of the pipeline. The sensing ring shall also be clamped into the body for the full radial width of the sensor. Pressure shall be transmitted to the gauge by a locked in and sealed fluid such as ethylene glycol or silicone oil. The annular seal shall be factory-assembled to the corresponding pressure instrument and be factory filled. The assembly shall be shipped with a tag stating "Do not disassemble for installation."

2. The annular ring shall be rated for ASME classes 150 and 300. It shall be constructed of carbon steel. Instrument connection shall be ¼" NPT.

3. The inside diameter of the sensor shall be the same as the mating pipe for a full uninterrupted flow. There shall be no dead ends or crevices, and flow passage shall make the sensor self-cleaning. The sensor shall have an auxiliary tapped and plugged port to allow connection of other equipment.

4. Wetted parts (liner) shall be capable for continuous duty handling a slurry containing 15 percent solids in a hydrocarbon oil similar to kerosene at temperatures up to 225 degrees F.

5. Acceptable Manufacturers:
   a. Ashcroft model 80.
   b. Or Approved Equal.

E. Pressure Transmitters

1. Electronic gauge or differential pressure transmitters shall consist of a capsule assembly, bottom works, vent plug, drain plug, cover flange, ½" NPT process connector and connection, amplifier unit, integral indicator, terminal box with cover, block and bleed valves, and conduit connections.

2. Transmitter shall be rated NEMA 4X. For hazardous locations, it shall be installed with an appropriate intrinsically safe barrier to guarantee the circuit may not abnormally create an ignition.

3. Transmitter shall be of a two-wire, 24VDC loop powered, producing 4 to 20 mA output proportional to the calibrated range of the instrument, capable of driving a 600 ohm load.

4. Static pressure rating shall be a minimum of 500 psig. The maximum over range pressure limit shall be a minimum of 150% of the range. Span shall be adjustable over a minimum of 5:1 range.

5. The 4 to 20 mA signal shall be capable of being calibrated electronically. Output signal damping shall be provided as an internal adjustment. Equipment shall be suitable for an ambient operating range of minus 40 degree F to plus 212 degrees F. The transmitter shall be equipped with the Hart protocol.

6. Accuracy, including linearity and repeatability, shall be a plus or minus 0.2 percent of span. Gauge pressure transmitters used for flow service shall include square root

extraction to produce an output signal linearly proportional to flow. Wetted parts, including block and bleed valve parts, shall be constructed of 316 stainless steel.

7. Acceptable Manufacturers
    a. Rosemount 2051.
    b. Or Approved Equal.

F. Pressure Switches

1. For unclassified locations, pressure switches shall be housed in a NEMA 4X enclosure. For classified locations, pressure switches shall be housed in a NEMA 7 enclosure.

2. Gauge and Differential pressures switches shall be diaphragm-actuated, dual adjustable, with SPDT snap action switch. Contacts shall be rated for a minimum of 5 Amps at 120 VAC. The dead band shall be adjustable up to 60 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 brass with a 1/4-inch bottom sensing connection, unless otherwise indicated.

3. Acceptable Manufacturers
    a. Ashcoft Series B (Gauge) and D (Differential).
    b. Or Approved Equal.

G. Pressure Gauges

1. Pressure gauges shall be 4-1/2 inches in diameter with white laminated dials and black graduations. Windows shall be shatterproof glass acrylic. 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 stainless steel material. Gauges shall perform as a liquid-filled gauge in a dry gauge and fight against vibration and pulsations. Gauges shall be calibrated to read in applicable units. Accuracy shall be plus and minus 1/2 percent range to 150 percent of the working pressure or vacuum of the pipe or vessel to which they are connected.

2. Acceptable Manufacturers
    a. Ashcroft 1279.
    b. Or Approved Equal.

2.3 TEMPERATURE PROCESS MEASUREMENT DEVICES

A. General

1. All temperature sensors or gauges to be used for monitoring temperature of liquids or gases shall be equipped with a thermowell. Thermowells shall have a minimum wall thickness between bore and outside of well of 3/16". . Wells shall have one-inch male NPT process connections except where line classification indicates some other type. Element connections shall be 1/2-inch female NPT. Material shall be Type 316 stainless steel unless the process requires otherwise. Flanged thermowells, where required, shall

meet material and size requirements of the line classification. Insertion length shall be specific to the application, not exceeding the manufacturer's published recommendations for the allowable length and for the line velocity.

B. Temperature Sensors and Transmitters

1. Temperature sensors shall be RTD’s and shall be 100 or 1000 ohm nominal at 0°C. 1000 ohm sensors shall be used wherever RTD wires to the transmitter or PLC type device exceed 50 feet. All RTD’s shall be setup as 3-wire installations.

2. Insertion type RTD’s shall be tip-sensitive, platinum 385 in ¼” 316SS sheath with watertight potting. Time constant in agitated water shall not exceed six seconds. RTD shall comply with International Practical Temperature Scale (IPTS) 68 standards. Accuracy shall be plus or minus 0.1 degree C. The RTD assembly shall be spring loaded for insertion into a thermowell.

3. RTD only assemblies (typically ran to an RTD input card on a PLC) shall have a stainless steel connection head rated NEMA 4X. It shall have a measuring range of -200°C to 1000°C.

4. Temperature transmitters shall be 2 wire devices with continuously adjustable span and zero adjustments, integral direct reading indicator, solid state circuitry, and a 4 - 20 mA DC output linearly proportional to the indicated temperature span. Transmitters shall be provided with 316 stainless steel thermowell, spring-loading device, extensions, union coupler, and explosion-proof aluminum connection head. Union shall extend out beyond the pipe lagging.

5. Acceptable Manufacturers
   a. Thermowells
      1)
   b. RTD only insertion assemblies
      1) Rosemount Series 78.
      2) Or Approved Equal.
   c. Sensor and Transmitter Assemblies
      1) Rosemount 3144P.
      2) Or Approved Equal.

C. Temperature Gauges

1. Thermometers shall have be a 7-inch vertical column with a single direct-reading scale and scale as indicated. Each shall be rust and corrosion-resistant with a leak-proof, hermetically sealed 316 stainless steel housing. The sensing element shall be silicone dampened for vibration resistance. Stem length shall be the maximum standard size compatible with the piping or vessel but shall not exceed 9-inches. Dial shall be adjustable 360 degrees around the stem axis and tiltable to 90 degrees from vertical to obtain the best viewing angle. Accuracy shall be plus or minus 1 percent of range. Each thermometer shall be provided with a thermowell.

2. Acceptable Manufacturers

a. Wika Model TI.901.
b. Or Approved Equal.

2.4 ROOM TEMPERATURE TRANSMITTERS

A. Provide room temperature transmitters in a single-gang corrosion resistant housing. The transmitters shall measure a range of 0 to 100 degrees Fahrenheit and shall be a loop powered 4-20mA transmitter. The transmitter shall utilize a 100 or 1000 ohm platimum 385 RTD.

B. Acceptable manufacturers
   1. BAPI Model BA/T1K[0 TO 100F]-R

PART 3 - EXECUTION

3.1 INSTALLATION

A. Equipment and materials specified in this section shall be installed, connected, and tested in accordance with the manufacturers' recommendations and as required by these specifications and contract drawings. Contractor shall coordinate with other trades to insure proper connection to piping and other mechanical equipment.

B. Install all analyzers/transmitters five feet off of floor level. Install in a location that is easily accessible while as near to the sensor(s) as possible.

3.2 CALIBRATION AND COMMISSIONING

A. A manufacturer representative shall field calibrate the process measurement system as required by section 409000 and per the manufacturer's documented calibration procedure. The system shall be calibrated to the proper ranges as required by the Owner and the Engineer. Where analog signals are connected to local or remote monitoring equipment, verify that the calibrated ranges and scaling of the local and remote indicators are correct.

B. Prior to final acceptance of the work, the Contractor shall certify the equipment and installation included under this section to be free of defects, and suitable for trouble-free operation.

3.3 FIELD QUALITY CONTROL

A. Tests and Inspections:

   1. Visually inspect the installation of the process measurement systems. Verify that the incoming power is within the required range. Verify the functionality of all output signals and communications connections.

   2. Test the process measurement system for proper operation at low, mid and high process conditions.

B. Document data for each measurement and for system calibration. Update the TR20 instrument forms following testing and calibration.

3.4 TRAINING

A. Provide a minimum of four hours of training for each type of process measurement system provided. Provide training in accordance with section 409000.

END OF SECTION 409119

SECTION 409123 – MISCELLANEOUS PROPERTIES PROCESS MEASUREMENT DEVICES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Dissolved Oxygen Process Measurement Devices.
2. Flow Process Measurement Devices.
3. Level Process Measurement Devices.
4. Turbidity Process Measurement Devices.
5. TSS Process Measurement Devices.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product indicated.

B. Instrumentation TR20 forms.

1.3 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

1.4 QUALITY ASSURANCE

A. Equipment to be furnished under this section shall be the product of firms regularly engaged in the design and manufacturing of this type of equipment. Manufacturer shall assume responsibility for, and guarantee performance of equipment furnished. However, this shall not be construed as relieving the Contractor from responsibility for the proper installation and functionality of the work.

B. Examine the Contract Documents and verify that instruments being provided are compatible with the physical and process conditions associated with the instrument. This includes compatibility with liquids, gases, pressures, temperatures, flows, materials, locations and mounting requirements. Provide all necessary accessories to the instrument for a complete and operable system.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Deliver the process measurement equipment as a complete system. Each system shall be properly tagged and identified with its corresponding instrument tag as shown on the P&ID's. Each system shall be factory calibrated and certified prior to delivery.

PART 2 - PRODUCTS

2.1 GENERAL

A. Each process measurement system shall typically consist of a sensor and an analyzer/transmitter. Where shown on the drawings, the analyzer/transmitter may be utilized for multiple sensors. When an analyzer/transmitter is used for multiple sensors, it shall be capable of displaying simultaneously each process measurement.

B. Each analyzer/transmitter shall be equipped with means to transmit process measurement information to the plant SCADA system.

1. For hardwired signals, unless otherwise indicated on the drawings, provide the following:
   a. 4-20mA output signal for each process measurement (for up to 500 Ohm loads)
   b. Two programmable SPDT relay outputs, rated at 5A up to 230VAC, for each process measurement

2. Where shown on the drawings, provide the following digital communications to the plant SCADA system:
   a. Modbus RTU (Two-Wire RS-485)

C. Each analyzer/transmitter shall be powered by 115VAC (+/- 10%) at 60Hz unless specifically shown on the drawings as being powered by 24VDC (+/- 15%). Each analyzer/transmitter shall retain its programmable settings in non-volatile memory.

D. Each sensor and corresponding analyzer/transmitter shall be supplied as a complete and operable system. This includes all cabling, mounting hardware and fasteners. When installed outdoors, the analyzer/transmitter shall be protected from the sun such that direct sunlight will not shine on the display.

E. All analyzers/transmitters shall be waterproof and made from corrosion resistant materials.

F. All sensors to be immersed in liquids shall be rated for permanent submersion and shall be corrosion resistant.

2.2 DISSOLVED OXYGEN PROCESS MEASUREMENT DEVICES

A. Each DO analyzer/transmitter shall be rated for operation with ambient temperature within -4°F to 122°F. If the analyzer/transmitter is to be installed in locations that may experience temperatures less than -4°F, it shall be housed in an enclosure which is equipped with a thermostatically controlled heater. If the analyzer/transmitter is to be installed in locations that may exceed 122°F, it shall be housed in an air conditioned enclosure. All enclosures and air conditioners shall be rated NEMA 4X.

B. The DO Sensor assembly shall meet the following criteria:

1. Contain the sensing elements and electronics for digital communications to the analyzer/transmitter in a self-contained, corrosion-resistant and submersible housing.

2. Built-in temperature compensation.
3. Allowed to be installed in liquids whose temperatures are 32 to 200°F and whose pressure is up to 100 psi.
4. The sensor shall have a measuring range of 0 to 20 ppm.
5. The sensor shall continuously measure dissolved oxygen by exciting a luminescent material and then detecting light emitted by the material that is proportional to the amount of dissolved oxygen in the liquid.

C. Shall not require sample conditioning or electrolyte solutions.

D. Acceptable Manufacturers:

1. Hach model LDO Probe 2 with SC200 or SC1000 analyzer/transmitter.

2.3 FLOW PROCESS MEASUREMENT DEVICES

A. ROTAMETERS

1. Rotameters in chemical solution lines and where indicated shall have vertical bottom inlets and top outlets with ANSI 150-lb flanged ends for vertical mounting.

2. The meters shall have Hastelloy C floats, 10-inch long scales, and a range of 10:1 with an accuracy of plus or minus 2 percent. Meters shall be rated for a minimum working pressure of 150 psi. Flanged rotameters for chemical solutions and where indicated shall be calibrated in gallons per minute.

3. The bodies shall have union ends for ease of maintenance, polysulphone tubes, aluminum or brass end fittings, Type 316 stainless steel internal parts and scales suitable for the indicated capacity range.

4. The meters shall have accuracy within plus and minus 5 percent of the capacity range indicated.

5. Meters in air and pump seal flushing lines shall be of the modified rotameter design with screwed ends, spring-loaded pistons, and union bodies for mounting in any position.

6. For activated carbon solution, bodies shall be Type 316 stainless steel construction with magnetically actuated float and scale.

7. For other chemicals bodies shall have Type 316 stainless steel ends with heavy borosilicate glass tubes and packing glands or other best suitable material.

8. Rotameters with NPT screwed ends for water, air, and fuel gas service shall be calibrated in gallons per minute or cubic feet per minute. The scales shall be suitable for the capacity ranges indicated.

9. Acceptable Manufacturers:
   a. Krohne VA40 Series.
   b. Dwyer UV Series.

c. Or Approved Equal.

B. OPEN CHANNEL FLOW METER

1. Ultrasonic type open channel flow meters

a. In applications where level measurement may be used to calculate flow, including flume and weir applications, an ultrasonic transducer and remote transmitter system shall be utilized. For the ultrasonic transducer and remote transmitter system, refer to the requirements of 2.4.E Ultrasonic Level Measuring System.

b. The ultrasonic open channel flow system shall be capable of internally converting the measured level into the calculated flow value and then displaying it on the screen. The meter shall output a 4-20mA signal that represents the flow rate. It shall also have a contact output that may be used for flow totalization.

c. Acceptable Manufacturers:
1) Siemens LUT400 (transmitter) with XPS-5 (transducer).
2) Or Approved Equal.

C. FLOW SWITCHES

1. Thermal dispersion type flow switches

a. Thermal dispersion type flow switches shall be used for pump discharge monitoring, chemical injection monitoring, gas flow monitoring and for flows in pipes with velocities greater than 0.25 fps.

b. The flow element shall be constructed of a material that is best suited for the liquid or gas that it is serving. Typically for chemicals the material will be Hastelloy C and for other liquids or gases it will be 316SS.

c. The switch shall be capable of operating in liquids or gases whose temperatures range from -40°F to 350°F and up to 2000 psi operating pressure.

d. The flow switch assembly shall be insertion type with ¾" male NPT threads. The insertion length shall be such that the thermal dispersion elements are in the center of the pipe.

e. The flow switch shall accept 115VAC or 24VDC as shown on the Contract Drawings. It shall have two SPDT relay outputs rated at 5A up to 240VAC.

f. The flow switch shall be rated to be installed in Class 1, Division I Groups B,C & D hazardous locations. The electronics shall be housed in a powder coated aluminum enclosure that is rated NEMA 4X.

g. Acceptable Manufacturers:
1) Fluid Components International (FCI) FLT93 Series.
2) Sierra Instruments Innova-Switch Series.
3) Or Approved Equal.

D. MAGNETIC FLOW METER

1. Materials

a. All mounting hardware shall be 316 stainless steel, the instrument enclosure and the spool mag shall be rated NEMA 4X, the flow sensor liner shall be hard rubber, and the electrode material shall be hastelloy.

b. Spool size shall be as specified on the drawings.

c. All applications with flow element below grade where no de-watering means or in submersible applications shall provide the flow element as NEMA 6P (IP-68).

d. Transmitter shall be integral or remote to the flow element as shown on the P&ID's.

2. Design and fabrication

a. Utilize characterized field principle of electromagnetic induction to produce signal directly proportional to flow rate. The meter shall use a pulsed DC magnetic field excitation.

b. Provide flanged end connections per ANSI B16 rated for piping system operating and test conditions.

c. Operating pressure: 150 psi.

d. Operating temperature: 122°F.

e. Grounding requirements: per manufacturer requirements. Typically inlet and outlet grounding rings of same material as electrode.

f. When the transmitter is remote to the flow element, provide cable between flow element and transmitter. Coordinate with the installer the length of the cable required. No splices in any way will be allowed.

g. Complete zero stability shall be inherent to the meter system. The system shall have a programmable low flow cutoff.

h. Empty pipe detection to prevent false measurement when pipe is empty or partially filled.

i. Forward and reverse flow measurement and totalization as well as net flow totalization.

j. 4-20mA DC isolated output into maximum 800 ohms. Signal shall be programmable to indicate forward and/or reverse flow.

k. Provide a dry contact output for flow direction indication.

l. Provide a programmable frequency output for flow totalization.

m. +/- 0.5% accuracy for flow rates above 1 fps.

3. Acceptable Manufacturers
   a. Endress+Hauser Promag 53.
   b. Rosemount 8700.
   c. ABB WaterMaster.
   d. Or Approved Equal.

E. INSERTION THERMAL MASS FLOW METERS

1. Materials

   a. All mounting hardware shall be 316 stainless steel, the instrument enclosure and the spool mag shall be rated NEMA 4X

2. Design and Fabrication

   a. Velocity Range: 0-18,000 SFPM (300 SFPS), air at standard conditions of 25°C and 760 mmHg.

   b. Velocity Measurement Accuracy: ±2% of reading from 10 to 100% of calibrated range.

   c. Output 4-20ma signal proportional to flow rate. 700 ohms maximum resistance.

   d. Power Supply 18 to 30 VDC

   e. Repeatability: 0.25% or better.

   f. Process Temperature Rating: -10°C to +120°C.

   g. Process Pressure Rating: 150 PSIG.

   h. Sensor Material: 316L Stainless Steel, all welded construction.

   i. Sensor Support Material: 316L Stainless Steel all-welded construction.

   j. Insertion Length: Per manufacturer's recommendations.

   k. Process Line Sizes: 3" pipe and larger.

   l. Sensor Electronics Enclosure: NEMA 4X, Class I, Div. 1, Groups B, C, D:

   m. Sensor Enclosure Temperature Rating: -20°C to +50°C.

   n. Process Connection: 316 Stainless Steel Compression Fitting to fit 1" FNPT Fitting on pipe (by customer).

o. Field Wiring: 1 pair of twisted and shielded 14-18 gauge wire having a maximum loop resistance of 4 ohms.

p. Safety approvals: Non-incentive: Class I, Div.2, GPS A,B,C,D,T5;CSA pending; Explosion-proof: Class I, Div. I, GPS B,C,D,T4, CSA pending; Flameproof: Eex d IIC T4; CENELEC pending.

3. Acceptable Manufacturers
   a. Fluid Component International ST98 Series with Display.
   b. Or Approved Equal.

2.4 LEVEL PROCESS MEASUREMENT DEVICES

A. FLOAT SWITCHES

1. Float switches shall consist of a mechanical switch, hermetically sealed in a plastic casing, freely suspended at the desired height from its own cable. When the liquid level reaches the float switch, the casing will tilt and the mechanical switch will change state.

2. The casing shall be constructed of polypropylene with the sheathed cable extruding from the casing. The cable shall be three conductors, made specifically for underwater use and heavy flexing service.

3. The float switch shall have a 10A resistive rating up to 250VAC.

4. Weight and buoyancy shall be such that contaminants like a cake of grease will not result in the float switch changing operating level more than one inch.

5. A NEMA 4X 316SS junction box shall be supplied for termination of the float cable(s) allowing for conventional wiring and conduit to be run from the junction box to a control panel. It shall have terminal blocks for the required number of circuits and shall accept sealed fittings.

6. Float switch cables shall be suspended in a manner that provides minimum strain to the cable and will not damage it. This is typically achieved with a stainless steel cord support grip or strain relief grip as manufactured by Kellems. When support grips are used, a stainless steel hook shall be installed for hanging the support. All screws, fasteners, boxes and grips shall be 316SS. In no way are any steel or galvanized steel components allowed.

7. The float cable length shall be long enough for easily removing the float from the water for testing and long enough to reach its termination junction box.

8. If the float switch is to be installed in a classified area, an appropriate intrinsically safe barrier shall be utilized to guarantee the circuit may not abnormally create an ignition.

9. Manufacturers:

a. Flygt ENM-10.
b. Or Approved Equal.

B. FLOOD SWITCHES

1. High level flood switches shall be the type that is suspended on a column. A ¼" NPT connection with flying leads allows the column and float assembly to be attached to a junction box. The junction box shall be rated NEMA 4X and be nonmetallic. The flood switch shall be CPVC and shall be made for use with liquid chemicals and corrosive liquids. Switch contacts shall be SPST N.O. with 20VA rating minimum.

2. If the flood switch is to be installed in a classified area, an appropriate intrinsically safe barrier shall be utilized to guarantee the circuit may not abnormally create an ignition.

3. Manufacturers:
   a. GEMS LS-74780.
   b. Or Approved Equal.

C. SUBMERSIBLE LEVEL TRANSMITTERS

1. The submersible level transmitter shall consist of a submersible transducer, electronic transmitter, support cable, and interconnecting cable with cable shield and vent tube for atmospheric reference. The vent tube shall be provided with a replaceable moisture barrier. The submersible transducer shall be the strain gauge type suitable for sensing pressure equivalent to the liquid level range indicated.

2. The transducer shall have 316 stainless steel process wetted parts and shall be provided with a waterproof interconnecting cable. The transducer shall be suspended by a corrosion resistant cable as recommended by the manufacturer. The installation shall allow easy removal of the transducer and cable assembly for maintenance purposes. The electronic level transmitter shall be remote mounted and shall produce a 4 - 20 mA DC signal linearly proportional to the level range indicated and be capable of driving a load of 700 ohms.

3. The interconnecting cable shall have a pull strength of 200 pounds, be factory attached to the transducer, and shall be terminated in a NEMA 4X 316SS enclosure. The enclosure shall house the vent tube moisture barrier and local indication.

4. The measurement system shall be suitable for the area classification and operation over a temperature range of 32 to 122 degrees Fahrenheit with an accuracy of plus or minus 0.5 percent of span. The transmitter shall have a non-fouling, large diaphragm (greater than 2"). The diaphragm shall be protected by a spacer assembly that also allows the transducer to sit on the floor of the wet well.

5. For lengths greater than 20 feet the transducer shall have ½" threads and shall be suspended in the wet well by ½" stainless steel conduit.

6. Acceptable Manufacturers
   a. Dwyer series PBLTX.
   b. Or Approved Equal.

D. FLANGED LEVEL TRANSMITTERS

1. Flanged level transmitters shall be a flanged, differential pressure-sensing unit. The transmitter shall be a 2 wire device with continuously adjustable span, zero and damping adjustments, integral indicator, scaled in engineering units, with a 4 digit LCD display, solid state circuitry, and 4 - 20 mA output with HART protocol. Accuracy shall be 0.075 percent of span. Process wetted parts, bolts, flanges, adapters, drains and vents shall be stainless steel. Body and mounting brackets shall be corrosion resistant and suitable for the environment. The flanged process connection shall be 316SST ANSI Class 150 4-inch with a 3” 316SST diaphragm. The diaphragm shall extend past the flange such that it is flush with walls of the pipe. The low pressure connection shall be 1/4-inch or 1/2-inch NPT.

2. Components**:** Diaphragm seals shall consist of a flange with flush or extended diaphragm to be flush with the walls of the pipe. It shall have a direct mount, coplanar, welded connection for connection of the transmitter to the seal.

3. Operating Principles: The diaphragm seal shall attach to the inlet connection of a pressure instrument to isolate its measuring element from the process fluid. The space between the diaphragm and the pressure element shall be completely filled with a suitable liquid that is rated for the environmental conditions. Displacement of the liquid fill in the pressure element through the movement of the diaphragm shall transmit process pressure changes directly to a gauge, transmitter, switch, or other pressure instrument.

4. Materials: Exposed surfaces, housings, and diaphragm shall be constructed of 316, stainless steel.

5. Acceptable Manufacturers
   a. Rosemount model 3051L with model 1199 diaphragm seal.
   b. Or Approved Equal.

E. ULTRASONIC LEVEL MEASURING SYSTEM

1. As indicated on the drawings, the ultrasonic level measuring system shall be setup as a level transducer with remote mounted transmitter or as a single transducer/transmitter assembly. For hazardous locations, the single transducer/transmitter shall be utilized. It shall be loop powered and shall be installed with an appropriate intrinsically safe barrier to guarantee the circuit may not abnormally create an ignition.

2. All transducer and transducer/transmitter assemblies shall be rated IP68 for permanent submergence. Remote transmitter shall be in a non-corrosive NEMA 4X housing. Transmitters shall have an LCD display and shall be programmable by buttons on the transmitter or with a handheld programmer. When programmed with a handheld programmer, each transmitter shall be supplied with an accompanying programmer.

3. The transducer shall be encapsulated in chemical and corrosion resistant material, such as Kynar, Teflon or TEFZEL. It shall be capable of operating from -40°F to 158°F. The transducer shall be compatible with the level range as indicated on the Contract Drawings. As a minimum, the transducer shall be capable of measuring a range of 40 feet.

4. When the transducer is remotely mounted from the transmitter, it shall have a waterproof shielded cable whose length is long enough to reach the transmitter. In no way shall splicing of the transducer cable be allowed.

5. Each transmitter shall provide a 4-20mA output signal that is programmable to a user desired level range.

6. Remote transmitters shall be provided to accept two transducers for differential level monitoring or for monitoring two separate levels. A second 4-20mA output signal shall be provided for the second level. The remote transmitter shall have six programmable relays rated at 5A up to 250VAC.

7. Manufacturers:
    a. Siemens SITRANS Probe LU (transducer/transmitter assembly); Hydroranger 200 (remote transmitter) with XPS-15 or greater (transducer).
    b. Or Approved Equal.

F. RADAR LEVEL MEASURING SYSTEM

1. The radar level measuring system shall be setup as a single loop powered transducer/transmitter assembly. For hazardous locations, it shall be installed with an appropriate intrinsically safe barrier to guarantee the circuit may not abnormally create an ignition.

2. All transducer/transmitter assemblies shall be rated IP68 for permanent submergence. Transmitters shall have an LCD display and shall be programmable by buttons on the transmitter or with a handheld programmer. When programmed with a handheld programmer, each transmitter shall be supplied with an accompanying programmer.

3. The transducer shall be encapsulated in chemical and corrosion resistant material and shall be hermetically sealed. The antenna supplied (horn or rod) shall be per the recommendation of the manufacturer. It shall be capable of operating from -40°F to 158°F. The transducer shall be compatible with the level range as indicated on the Contract Drawings. As a minimum, the transducer shall be capable of measuring a range of 40 feet.

4. Coordinate with the mechanical installers the method of installing the radar system (flanged or threaded connection). It is critical that the radar level measuring system be installed according to the manufacturer's installation guidelines. Install shield sections if required. Keep the radar emission cone free of interference from pipes, beams, pouring liquids, etc. Locate the assembly away from side walls of tanks or vessels.

5. Each transmitter shall provide a 4-20mA output signal that is programmable to a user desired level range.

6. Provide a software package by the same manufacturer as the radar system that is used to commission and maintain the system. The software shall be able to configure the system, view radar echo profiles and modify the programming to suppress false echos.

7. Manufacturers:
   a. Siemens SITRANS LR200 with SIMATIC PDM Software
   b. Or Approved Equal.

2.5 TURBIDITY PROCESS MEASUREMENT DEVICES

A. Each turbidity analyzer/transmitter shall be rated for operation with ambient temperature within -4°F to 122°F. If the analyzer/transmitter is to be installed in locations that may experience temperatures less than -4°F, it shall be housed in an enclosure which is equipped with a thermostatically controlled heater. If the analyzer/transmitter is to be installed in locations that may exceed 122°F, it shall be housed in an air conditioned enclosure. All enclosures and air conditioners shall be rated NEMA 4X.

B. The Turbidity Sensor assembly shall meet the following criteria:

   1. Contain the sensing elements and electronics for digital communications to the analyzer/transmitter in a self-contained, corrosion-resistant housing.
   2. The turbidity sensor shall be meet the performance criteria of the U.S. Environment Protection Agency in Method 180.1, making it suitable for regulatory reporting.
   3. The sensor shall utilize a light source that directs light through the process water to a submerged photocell which detects the amount of light that passes through the water.
   4. Allowed to be installed in liquids whose temperatures are 32 to 122°F.
   5. The sensor shall have a measuring range of 0 to 100 NTU.
   6. Shall not require sample conditioning or electrolyte solutions.

C. Acceptable Manufacturers:
   1. Hach model TU5300 Turbidity System with SC200 or SC1000 analyzer/transmitter.

2.6 TSS PROCESS MEASUREMENT DEVICES

A. Each Total Suspended Solids (TSS) analyzer/transmitter shall be rated for operation with ambient temperature within -4°F to 122°F. If the analyzer/transmitter is to be installed in locations that may experience temperatures less than -4°F, it shall be housed in an enclosure which is equipped with a thermostatically controlled heater. If the analyzer/transmitter is to be installed in locations that may exceed 122°F, it shall be housed in an air conditioned enclosure. All enclosures and air conditioners shall be rated NEMA 4X.

B. The TSS Sensor assembly shall meet the following criteria:

   1. Contain the sensing elements and electronics for digital communications to the analyzer/transmitter in a self-contained, corrosion-resistant and submersible housing.
   2. Built-in temperature compensation.
   3. Allowed to be installed in liquids whose temperatures are 32 to 104°F and whose pressure is up to 14 psi.
   4. The sensor shall have a measuring range of 0 to 50 g/L.
   5. Shall not require sample conditioning or electrolyte solutions.
   6. Shall have a self-cleaning mechanism for preventing the sensor from fouling.

C. Acceptable Manufacturers:
1. Hach Solitax System with SC200 or SC1000 analyzer/transmitter.
2. WTW/Xylem model ViSolid 700 IQ pH System with 182 or 2020 analyzer/transmitter.

2.7

PART 3 - EXECUTION

3.1 INSTALLATION

A. Equipment and materials specified in this section shall be installed, connected, and tested in accordance with the manufacturers' recommendations and as required by these specifications and contract drawings. Contractor shall coordinate with other trades to insure proper connection to piping and other mechanical equipment.

B. Install all analyzers/transmitters five feet off of floor level. Install in a location that is easily accessible while as near to the sensor(s) as possible.

3.2 CALIBRATION AND COMMISSIONING

A. A manufacturer representative shall field calibrate the process measurement system as required by section 409000 and per the manufacturer's documented calibration procedure. The system shall be calibrated to the proper ranges as required by the Owner and the Engineer. Where analog signals are connected to local or remote monitoring equipment, verify that the calibrated ranges and scaling of the local and remote indicators are correct.

B. Prior to final acceptance of the work, the Contractor shall certify the equipment and installation included under this section to be free of defects, and suitable for trouble-free operation.

3.3 FIELD QUALITY CONTROL

A. Tests and Inspections:

1. Visually inspect the installation of the process measurement systems. Verify that the incoming power is within the required range. Verify the functionality of all output signals and communications connections.

2. Test the process measurement system for proper operation at low, mid and high process conditions.

B. Document data for each measurement and for system calibration. Update the TR20 instrument forms following testing and calibration.

3.4 TRAINING

A. Provide a minimum of four hours of training for each type of process measurement system provided. Provide training in accordance with section 409000.

END OF SECTION 409123

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SECTION 409433 – HUMAN-MACHINE INTERFACES

PART 1 - GENERAL

1.1 SUMMARY

A. This section covers the human-machine interfaces (HMI) used for control and monitoring as indicated on the Contract Documents. HMI's include the following:
   1. Operator Interface Terminals (OIT) or touch screens.
   2. Personal Computers or Servers used as HMI's to the SCADA System.

B. For software related to HMI equipment, refer to Section 409600.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product indicated.

1.3 QUALITY ASSURANCE

A. Hardware to be furnished under this section shall be the product of firms regularly engaged in the design and manufacturing of this type of equipment. Manufacturer shall assume responsibility for, and guarantee performance of equipment furnished. However, this shall not be construed as relieving the Contractor from responsibility for the proper installation and functionality of the work.

B. Examine the Contract Documents and verify that HMI equipment and software being provided is compatible with the requirements. Provide all necessary accessories to the HMI equipment for a complete and operable system.

1.4 DELIVERY, STORAGE, AND HANDLING

A. Deliver the HMI hardware as a complete system in accordance with Section 409000.

PART 2 - PRODUCTS

2.1 OPERATOR INTERFACE TERMINALS

A. OITs shall be furnished with hardware to monitor and control equipment, as listed in the specifications, and shown on the Contract Drawings.

B. OITs shall be 10" color touch screens unless otherwise indicated on the Contract Drawings. Each OIT shall have the following features:
   1. Has serial and Ethernet ports with built-in communications protocols drivers as required by the project.

2. Has associated software for programming the OIT and its screens, database, alarms, etc.
3. Has a 640 x 480 minimum resolution with TFT color screen.
4. Has at least 64MB of memory.
5. Has no limitations on the number of screens or tags that may be used as long as within the memory limitations of the OIT.

C. Acceptable Manufacturers
1. Allen Bradley Panelview Plus 7

2.2 SCADA PC HARDWARE

A. SCADA PC hardware shall be provided by the Owner's System Integrator

PART 3 - EXECUTION

3.1 INSTALLATION

A. OIT's and Panel PC's shall be installed on the doors of control panels as shown in the Contract Drawings. The control panel assembly and installation shall be as required by Section 409513.

B. Following control panel Factory Acceptance Testing, OIT's and Panel PC's shall be removed from the control panels and put back in their original packaging and shipped to the Site loose. The OIT's and Panel PC's shall not be re-installed until they are needed for loop testing. The goal of doing this is to protect the screens from damage during construction. While the OIT's and Panel PC's are not in the control panel, cover and seal the open space on the door of the control panels to protect the interior of the panel.

C. OIT's and Panel PC's]shall be installed in accordance with the manufacturer's installation guidelines and instructions.

3.2 TRAINING

A. Provide training for the OIT and SCADA PC hardware supplied for the project as required by Section 409000.

END OF SECTION 409433

SECTION 409443 – PROGRAMMABLE LOGIC CONTROLLERS

PART 1 - GENERAL

1.1 SUMMARY

A. This section covers the programmable logic controllers (PLC) used for control and monitoring as indicated on the Contract Documents.

B. Provide one full version of PLC programming software that is applicable to the PLC hardware being supplied for the project. Include auxiliary software (such as communications software, drivers, networking configuration software, etc.) that may be required for a complete and operable system.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product indicated.

B. Wiring diagrams showing connections to all devices; input and output (I/O), analog and discrete. The wiring diagrams shall indicate the I/O address point to be used in the PLC programs.

C. Submit calculations that show the following:
1. PLC Power Supply Budget
2. Calculated number of I/O quantities required
3. Estimated PLC memory usage

1.3 QUALITY ASSURANCE

A. Hardware and software to be furnished under this section shall be the product of firms regularly engaged in the design and manufacturing of this type of equipment. Manufacturer shall assume responsibility for, and guarantee performance of equipment furnished. However, this shall not be construed as relieving the Contractor from responsibility for the proper installation and functionality of the work.

B. Examine the Contract Documents and verify that PLC equipment and software being provided is compatible with the requirements. Provide all necessary accessories to the PLC equipment for a complete and operable system.

1.4 DELIVERY, STORAGE, AND HANDLING

A. Deliver the PLC hardware and software as a complete system in accordance with Section 409000.

PART 2 - PRODUCTS

2.1 GENERAL

A. PLCs shall be furnished with hardware and software necessary to monitor and control equipment, as listed in the specifications, and shown on the Plans.

B. Each field input and output shown as an I/O Point shall be connected as per the manufacturers' recommendations.

C. The Contractor shall provide the hardware, software, and installation necessary for connecting additional future equipment as indicated on the Plans. In addition to allocating for future I/O, each PLC shall be supplied with a minimum of 20% spare I/O of each type. In other words, the total I/O for each type shall be (current I/O + future I/O) * 120%. Provide enough panel space to install up to 200% of future I/O modules and/or PLC racks/bases.

D. The type of field input and output shall be defined as follows unless specified otherwise on the plans:
   1. Analog inputs and outputs: 4-20mA DC.
   2. Discrete inputs: I/O device shall be a dry contact, inputs shall be powered by the PLC at 24VDC (preferred) or 120VAC.
   3. Discrete outputs: Isolated dry contact outputs.

E. All PLC I/O shall have I/O modules that are installed and wired at a UL508 Panel Shop. All I/O points shall be wired down to terminal blocks. In no way should field wiring go to any part of the PLC assembly.

F. Vendor and Contractor supplied PLC's shall meet the requirements of this Section and of Division 40. Vendor supplied PLC's shall have a Factory Acceptance Test (FAT) performed by the Vendor as required by Section 409000. Contractor supplied PLC's shall have a FAT performed by the Contractor as required by Section 409000.

G. The PLC shall be capable of handling online program modifications without taking the system offline or requiring a download.

H. Acceptable Manufacturers
   1. Allen Bradley ControlLogix

2.2 PROCESSORS

A. The PLC processor shall be a microprocessor based industrial controller with a temperature rating of 0 to 60 degrees C, and a humidity rating of 5 to 85% non-condensing, minimum.

B. The processor's memory shall be sized according to the number of I/O points and amount of logic required for the application. As a minimum, the memory shall be at least 3 megabytes.

C. The processor shall retain its memory and programming when power is removed.

D. The processor shall have tag-based memory.

E. Processors shall be the ControlLogix L8 Series

2.3 PLC POWER SUPPLY

A. The power supply shall provide power for the processor, and I/O modules. The power supply shall have built-in over voltage and under voltage detection circuitry, protection against overcurrent conditions, and automatic power-up sequence that enables outputs only when proper operating tolerances are reached. Power requirements shall be 24 VDC unless shown as otherwise on the Contract Documents.

2.4 COMMUNICATIONS NETWORKS

A. Each PLC shall be equipped with network ports (and corresponding network modules if necessary) as shown on the Contract Drawings. Each PLC shall be equipped with an Ethernet port for connection to the Plant SCADA System.

B. Ethernet ports shall be setup to communicate with the Allen-Bradley Ethernet/IP protocol.

C. The PLC shall be programmable through the Ethernet port or through a USB port.

2.5 INPUT/OUTPUT MODULES

A. Only I/O modules that have typical wiring diagrams shown in the Contract Drawings shall be allowed for each PLC.

B. Analog I/O modules shall have a minimum of 12 bits of resolution and shall be setup as 4 to 20 mA signals unless indicated otherwise on the Contract Drawings. Analog inputs shall be setup to be connected to loop powered (2-wire) or self-powered (4-wire) signals. All analog inputs and outputs shall be protected by a fuse. 4 to 20 mA signals shall be protected by a 32mA fuse.

C. Each discrete I/O module shall be fused (fuse body shall be equipped with a blown fuse indicator). Each discrete output module and shall have interposing relays for each point with form C relay contacts. Indicator lights shall also be provided on each I/O point to indicate status of each signal. Each individual input or output point shall be optically isolated to protect the controller I/O circuitry from high voltage transients.

2.6 SPARE PARTS

1. In addition to the spare parts requirements of Section 409000, provide the following:
   a. One spare processor for each type of PLC processor supplied for the project.
   b. One spare I/O card for every type of I/O card supplied for the project.
   c. One spare PLC power supply for every type supplied for the project.
   d. One spare network adapter for each type of network adapter supplied for the project.
   e. One spare base for rack style PLC’s.

PART 3 - EXECUTION

3.1 FACTORY ACCEPTANCE TESTING

A. All PLC assemblies shall be built up in control panels and shall be part of a Factory Acceptance Test as required by Section 409000.

3.2 INSTALLATION

A. The PLC assemblies shall be installed in control panels made specifically for the PLC. The control panel assembly and installation shall be as required by Section 409513.

B. The PLC assemblies shall be installed in accordance with the manufacturer's installation guidelines and instructions.

3.3 TRAINING

A. Provide training for the PLC hardware supplied for the project as required by Section 409000.

END OF SECTION 409443

SECTION 409513 – PROCESS CONTROL PANELS AND HARDWARE

PART 1 - GENERAL

1.1 SUMMARY

A. This section includes the requirements for all control panels and associated hardware for the project. This includes, but is not limited to, vendor control panels, PLC panels, local control panels and instrumentation panels.

B. Related Requirements:
   1. The requirements of Division 26 shall apply to this section.

1.2 ACTION SUBMITTALS

A. Submit the Control Panels Submittal as required by Section 409000.

1.3 CLOSEOUT SUBMITTALS

A. Submit the operation and maintenance data, including record control panel drawings for all control panels as required by Section 409000.

1.4 QUALITY ASSURANCE

A. Referenced Standards:

   1. National Electric Code (NEC).
   2. American Society for Testing and Materials (ASTM).
   3. Joint Industrial Council (JIC).
   4. National Electrical Manufacturers Association (NEMA):
      a. ICS 4, Terminal Blocks for Industrial Use.
      b. ICS 6, Enclosures for Industrial Controls and Systems.
      c. 250, Enclosures for Electrical Equipment (1000 V Maximum).
   5. Underwriters Laboratories Inc. (UL):
      a. 50, Enclosures for Electrical Equipment.
      b. 508, Industrial Control Equipment.
      c. 508A, Standard for Industrial Control Panels.

B. Hardware to be furnished under this section shall be the product of firms regularly engaged in the design and manufacturing of this type of equipment. Manufacturer shall assume responsibility for, and guarantee performance of equipment furnished. All panels shall be assembled in and labeled by a listed UL 508A panel shop. However, this shall not be construed as relieving the Contractor from responsibility for the proper installation and functionality of the work.

C. Examine the Contract Documents and verify that control panel hardware being provided is compatible with the requirements. Provide all necessary accessories to the control panels for a complete and operable system.

D. The Contractor shall not place any conduit feeds for any control panel until the Control Panel Submittal has been approved. Once approved, conduits shall be placed strategically to best suit the layout of the control panel. Power entry and separation of power, controls and signal shall be considered.

E. All painted control panels shall have matching paint colors and tones.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Deliver the control panel hardware as required by Section 409000.

PART 2 - PRODUCTS

2.1 GENERAL

A. All control panels shall have an overall NEMA rating suitable for withstanding the mechanical, electrical, thermal stresses, humidity and corrosion that the panel will be subjected to in its installed location.

B. The following rules shall be followed when determining the NEMA rating requirement for each control panel:

1. NEMA 1, 3 & 3R shall not be allowed for control panels.
2. NEMA 4 shall be utilized for outdoor or wet locations in non-corrosive, unclassified areas. NEMA 4 control panels shall be painted steel.
3. NEMA 4X shall be utilized in corrosive, unclassified areas. NEMA 4X enclosures shall be 316SS except for the following exceptions with which the enclosure shall be polycarbonate or fiberglass reinforced polyester (FRP):
   a. Chemical areas or rooms.
   b. Locations where stainless steel is incompatible.
   c. Where specifically noted on the Contract Drawings.
4. NEMA 7 shall be utilized for classified areas as required by NEC. NEMA 7 enclosures shall be constructed of cast aluminum.
5. NEMA 12 shall be utilized in dry, non-corrosive, unclassified areas. NEMA 12 control panels shall be painted steel.

C. 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 external conductors. The SUPPLIER shall provide sufficient terminal blocks to connect 30 percent additional conductors for future use.

D. PLC Discrete outputs from the control panel shall be provided by electrically-isolated contacts rated for 10 amps at 120 VAC. Analog inputs and outputs shall be isolated 4 to 20 mA, 2 wire signals with power supply.

E. Control panel mounted devices shall be mounted a minimum of 3-feet above finished floor elevation. Touchscreens shall be mounted at a height of 66" from the finished floor to the center of the touchscreen. All control panels will be situated on housekeeping pads, this is not considered the finished floor elevation.

2.2 ENCLOSURES

A. Enclosures shall be either freestanding, pedestal-mounted or equipment skid-mounted, as indicated. Internal control components shall be mounted on an internal back-panel or side-panel as required.

B. Enclosure dimensions indicated on the Contract Drawings are based upon non-certified information and shall be considered the minimum panel size. It is the responsibility of the Contractor to design the size of all control panels. When sizing the control panels, adhere to the following criteria:
   1. Maximum panel depth is 24". If there are special reasons for a deeper enclosure, approval must first be obtained from the Engineer.
   2. The panel size shall provide space for all equipment, wire-ducts, wire, terminations, and space for future expansion.
   3. If the panel size needs to be enlarged, coordinate with the installing Contractor that there is adequate space for the larger size. If there is not space, coordinate with the Engineer to come up with a solution.

C. Materials
   1. Steel panel section faces shall be 12-gauge minimum thickness for free standing panels and 14-gauge minimum thickness for wall-mounted or pedestal-mounted panels. Materials shall be selected for levelness and smoothness.
   2. Structural shapes and strap steel shall comply with ASTM A 283 - Low and Intermediate Tensile Strength Carbon Steel Plates, Grade C.
   3. Bolting Material: For outdoor, wet or corrosive areas, all bolting materials shall be 316SS. In dry, non-corrosive locations, carbon stell may be used. Commercial quality bolts, nuts, and washers shall be 1/2-inch diameter with UNC threads. Carriage bolts shall be used for attaching end plates. 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. Control panels shall be structurally designed such that the completed and installed control panels shall safely withstand seismic requirements for the project. All equipment mounted within the panel shall be properly braced to prevent damage during a seismic event.

D. Acceptable Manufacturers
   1. Hoffman.
   2. Saginaw.
   3. Or Approved Equal.

2.3 CONTROL PANEL ASSEMBLY

A. General

1. The following requirements must be met when mounting to the back panels or side panels of the control panel:
   a. Holes shall be drilled and tapped with less than 50% diminishment in thread.
   b. Backpan shall be cleaned front and back after any drilling and tapping.
   c. Tek Screws are not acceptable.
   d. Any component mounted to a back panel or side panel shall be mounted at an exact square to the vertical and horizontal planes.
   e. Any duct running between back panels and side panels shall align horizontally with no overlaps.
   f. All DIN rail mounted to the panels shall have ½" stand-offs allowing for wires and other equipment to be routed beneath the rail if necessary.
2. Enclosure doors shall be flush fitting, gasketed, and be of the hinged lift-off type with lockable door handles. A common key shall be provided for the doors on each 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 panels shall be straight and smooth. Corners shall be welded and ground smooth.
   b. The face of the panel shall be true and level after flanging.
   c. 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. Panels shall be self-supporting as defined below.\
3. Control panels that are supplied with three phase power and/or are powering motor loads shall be supplied with a main feeder disconnect that is door operated. The door operator for the disconnect shall be defeat-able with a screwdriver. If the upstream overcurrent protection device feeding the control panel is not in the same room as the control panel, provide a main circuit breaker as part of the main disconnect assembly. Fused disconnects shall not be used unless specifically shown on the Contract Drawings.

B. Preparation of Bare Metal Panel Surfaces

1. Grind high spots, burrs, and rough spots.
2. Sand or sandblast to a smooth, clean, bright finish.
3. Every trace of oil shall be removed with a solvent.
4. Apply the first coat of primer immediately.

C. Panel Finishing

1. Repair damaged primer on inside surfaces.
2. Apply primer to the entire panel surface.
3. Apply 2 coats of satin finish lacquer enamel over the entire surface.
4. Colors shall match original paint color.

D. Instrument Finishing: The final coat applied to painted surfaces 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.

E. Mounting of Instruments

1. The panel shop shall provide cutouts and shall mount instrument items indicated to be panel mounted, including any instruments indicated to be furnished by other vendors but installed in the panel.
2. The panel shop shall also mount behind the panels other instrument accessory items as required.
3. Equipment mounted at the rear of panel shall be installed to allow for commissioning adjustments, servicing requirements, and cover removal
4. Spare space shall be kept clear of wiring, etc., to give maximum space for future additions.
5. All equipment mounted with fasteners shall be mounted with grade 5 or greater Phillips head fasteners.

F. Electrical Requirements
1. Each panel shall be serialized with its own UL serial number and label.
2. Each terminal block shall have a printed label as shown on the panel drawings. Hand written labels in any location of the panel will not be accepted. Wiring shall be identified with printed tubular wire end markers.
3. Back panels and side panels shall have visible machine printed adhesive labels that detail the following items:
   a. Terminal block torque ratings for field connections.
   b. Terminal block sections as detailed in the panel drawings.
   c. All equipment within the panel including, but not limited to, PLCs, switches, circuit breakers, UPS, Power Supplies, and any other piece of equipment.
4. Screw torque shall not exceed 0.4 N*M (4.4 Lb*In) (7 Lb-In).
5. Wire duct for AC signals and wiring shall be light grey. All duct for DC signals shall be white. Wiring for AC circuits and DC circuits must be kept within their respective ducts.
6. Freestanding panels shall be provided with switched lighting as indicated in the panel drawings.
7. Freestanding panels shall be provided with a 15 amp, 120 volt, service outlet circuit within the back-of-panel area as shown in the panel drawings.
8. Wall-mounted or pedestal-mounted panels shall be sized to adequately dissipate heat generated by equipment mounted in or on the panel.
9. Outdoor panels shall be provided with thermostatically-controlled heaters to maintain inside temperatures between above 40°F.
10. Any panel with heat producing equipment such as a PLC, UPS or VFD shall have cooling capabilities to maintain the inside temperature below 104°F.
11. All outdoor panels equipped with heating and/or cooling shall be insulated with a minimum R value of 2.0.
12. Provide a laminated fuse list matrix detailing fuse numbers and sizes mounted on the inside of the enclosure door. The fuse list matrix must be easily visible and at minimum size 14 font. Hand written fuse matrices will not be accepted. See panel drawings approximate locations.
13. Provide a pocket mount on the inside of each panel door large enough to hold type 8.5 x 11 size paper. See panel drawings for approximate locations. Pockets must be accessible with no equipment obstructing the entrance of the pocket for at least ten inches above the pocket. The pocket mount shall be fastened. No adhesive type pockets allowed.
14. Where required crimped fork or ring terminals will be properly installed on the conductors for connection integrity.
15. Signal and Control Circuit Wiring

a. Wire type and sizes: Conductors shall be flexible stranded tin machine tool wire, UL 1015 listed Type MTW, and shall be rated 600 volts. Wires for instrument signal circuits and alarm input circuits shall be 14 AWG. Other wires, including shielded cables, shall be 16 AWG minimum.
b. Wire Insulation Colors: Conductors supplying 120 VAC power on the line side of a disconnecting switch shall have a black insulation for the ungrounded conductor. Grounded circuit conductors shall have white insulation. Insulation for ungrounded 120 VAC control circuit conductors shall be red. Wires energized by a voltage source external to the control panel shall have yellow insulation. Insulation for DC conductors shall be blue.
c. Wire Marking: Wire numbers shall be marked using white numbered wire markers made from plastic-coated cloth, Brady Type B 500 or equal, or shall be heat shrink plastic. Wire labels must be machine printed. All conductors within the control panel are to be permanently marked with wire labels at each end. Wire labels are to correspond to the labels on the approved shop drawings.
d. For case grounding, panels shall be provided with a ground lug complete with solderless connector for one no. 1 AWG bare stranded copper cable.
e. Panel doors shall be connected to panel ground.
f. Wire Fastening: Provision shall be made utilizing cable tie bases such as type CTM1 or equivalent, fastened inside the wire duct to allow for the fastening of the shop wire harnesses upon final installation.

16. Power Supply Wiring
    a. Unless otherwise indicated, control power shall be 120 VAC. Where the electrical power supply to the control panel is something other than 120 VAC, the control panel shall be provided with a control panel transformer. Control conductors shall be provided in accordance with the indicated requirements.
    b. 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.
17. Signal Wiring
    a. Signal wire shall be shielded twisted pair or triads. Cable shall be 18 AWG copper signal wires.
    b. Color code for instrument signal wiring shall be as follows:
        1) Positive (+) – Red or Clear
        2) Negative (-) – Black
    c. Multiconductor cables where indicated shall consist of no. 16 AWG copper signal wires twisted in pairs with 90-C, 600 V fault insulation. A copper drain wire shall be provided for the bundle with a wrap of aluminum polyester shield. The overall bundle jacket shall be PVC.
    d. RTD cabling shall be Belden 8770 cabling or equal.
    e. Multi-conductor cables, wireways, and conduit shall be sized to allow for 25 percent spare signal wire.
18. 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.
19. Wiring to rear terminals on panel-mount instruments shall be in plastic wireways secured to horizontal brackets above or below the instruments in about the same plane as the rear of the instruments.

G. Labor and Workmanship: Panels shall be fabricated, piped, and wired by fully qualified workmen who are properly trained, experienced, and supervised.

2.4 CONTROL PANEL COMPONENTS

A. Nameplates and labels

1. All control components within the control panel shall be labeled with adhesive labels that have a thermal transfer type ink system on a UL-508A approved label. Labels shall be provided for marking wire ducts, terminal block sections, PLC modules, networking modules, signal isolators, intrinsic barriers, relays, breakers, power supplies, surge suppressors and all other pertinent components within the control panel.
2. All components on the exterior of the control panel shall have nameplates fabricated from black-letter, white-face laminated plastic engraving stock, Rowmark Ultramatte or equal. Engraved characters shall be block style with no characters smaller than 1/8 inch. Adhesive shall be high strength, low profile double strength, double sided as produced by Bron or Tessa or approved equal. Stainless steel fasteners shall be used in addition to the adhesive on all equipment where the fasteners do not derate the NEMA rating of the enclosure.

B. Pilot Devices

1. Provide pilot devices from a single manufacturer.
2. Pilot devices shall have NEMA ratings that match the overall control panel rating. They shall be 30mm in diameter and heavy duty.
3. All pilot devices shall have an associated nameplate that clearly describes the function of the device.
4. Pilot lights shall be LED and shall have colors as follows:
    a. The Contract Drawings shall take precedence for light colors. Refer to the P&ID's and schematics.
    b. On/Running/Opened: Green.
    c. Off/Stopped/Closed: Red.
    d. Power: White.
    e. Alarm/Fail: Red.
5. Acceptable Manufacturers
    a. Square D Types K (for NEMA 4 or 12) or Types SK (NEMA 4X).
    b. Allen-Bradley Types 800T (NEMA 4/12) or Types 800H (NEMA 4X, 7).
    c. Or Approved Equal.

C. Door Mounted Meters

1. Digital Process Meters
    a. Provide digital process meters to display a numeric process value as required by the Contract Drawings.
    b. The meter shall accept and re-transmit an analog input signal which is in proportion with the process value. The meter shall be capable of receiving the following signals:
        1) 0 or 4 to 20 mA current.
        2) 0 to 5 or 10 DC volts.
        3) RTD and Thermocouple type inputs.
    c. The meter shall be programmable to scale the numeric display to process engineering units. It shall be capable of showing up to three decimal points.
    d. The meter shall be capable of powering the input and re-transmitted signal.
    e. Acceptable Manufacturers:

1) Precision Digital Trident Series.
2) Red Lion PAX Series.
3) Or Approved Equal.

2. Elapsed Time Meters (ETM)
   a. Provide ETM's for each motor and/or machine provided for the project. Each ETM shall accumulate hours in tenths of an hour.
   b. The ETM enclosure shall be panel mount, polycarbonate, shock resistant and totally sealed.
   c. Acceptable Manufacturers:
      1) Hobbs 20000 Series.
      2) Or Approved Equal.

D. Terminal Blocks

1. Terminal blocks shall mount on standard DIN rail, and be of the size required for conductors therein. A minimum of 25 percent spares shall be provided in each terminal box. No more than 2 conductors shall be allowed per termination. Jumper bar assemblies shall be installed for interconnecting terminal blocks, distributing power and signal commons. Terminal blocks shall be U.L. rated for 600 Volts, and 30 Amps, minimum.
2. Grounding terminal blocks shall be provided for instrumentation cable shields. The terminal blocks shall have distinctive 2-color bodies yellow and green, and shall be mounted to the DIN rail with metal screw down type clamps, providing a positive ground connection. One grounding terminal block shall be installed for every 2 instrument cables terminated. Grounding terminal blocks shall be U.L. rated for 600 Volts, and 20 Amps, minimum.
3. Terminal blocks shall be available in a variety of colors, including red, green, blue, gray, black, yellow, and orange.
4. DIN mount fuse holders shall have blown fuse indicators for DC and AC circuits. Fuse holders shall be of the compression clamp type. Fuse holders shall be U.L. listed, and rated for 600 Volts. Fuse sizes shall not exceed the U.L. current rating for the fuse holders.
5. Terminal blocks for 4 to 20 milliamp signals shall have knife disconnect switches, and accessible test points for testing and measurement of current loop signals, without the need for removing wire terminations.
6. Approved Manufacturers
   a. Phoenix Contact UT Series.
   b. Allen-Bradley 1492 Series.
   c. Or Approved Equal.

E. DIN Rail

1. DIN rail shall be prepunched, RoHS compliant, treated with galvanic zinc plating and passivation. Symmetrical DIN rail shall be 35 mm X 15 mm.
2. Acceptable Manufacturers
   a. Iboco Omega 3AF.
   b. Or Approved Equal.

F. Wire Ducts

1. Wire ducts shall have narrow slots (approximately every ½”) to accommodate high-density terminal blocks and other hardware.
2. Wire ducts shall be made of lead-free PVC, shall be UL rated for continuous use up to 122°F, and shall be flame retardant.
3. Wire duct colors shall be as follows:
    a. Light grey for all wiring 120V and higher.
    b. White for all wiring 48V and lower.
    c. Blue for all intrinsically safe wiring.
4. Acceptable Manufacturers
    a. Panduit Type F Series.
    b. Or Approved Equal.

G. Surge Protection Devices

1. Provide a Surge Protection Device (SPD) for power feeds which feed power to the control panel.
2. Each SPD shall have a short circuit current rating that exceeds the rating of the power feed that it is protecting.
3. All SPD’s shall be properly grounded to the ground grid per NEC and per the SPD manufacturer’s recommendations.
4. Three phase power feeds and single phase power feeds for non-sensitive loads.
    a. Provide a parallel, DIN rail mountable, SPD whose location is immediately downstream of the main panel disconnect or circuit breaker.
    b. Capable of handling a 10kA surge current.
    c. Acceptable Manufacturers
        1) Transtector 12R Series.
        2) Or Approved Equal.
5. Single phase power feeds for control panels with sensitive electronics
    a. Provide an inline, DIN rail mountable, SPD that also provides EMI filtering.
    b. The SPD shall be capable of handling a 10kA surge current.
    c. The inline SPD shall have a set of dry contacts that indicate when the unit is healthy and operating correctly.
    d. Acceptable Manufacturers
        1) Phoenix Contact SFP Series.
        2) Or Approved Equal.
6. Low Voltage Signals
    a. Provide surge protection for low-voltage signals where shown on the Contract Drawings.
    b. Acceptable Manufacturers
        1) Phoenix Contact Termitrab.
        2) Or Approved Equal.
7. Coaxial Transmission Lines
    a. For radio type systems, provide surge/lightning protection for all coaxial lines leaving the control panel.
    b. Surge/lightning protectors shall be rated for the frequency at which signals are to be transmitted on the cabling.
    c. Acceptable manufacturers
        1) Polyphaser.
        2) Or Approved Equal.

H. Circuit Breakers

1. Circuit breakers shall meet the requirements of Section 262816.
2. Provide a main circuit breaker with panel disconnect if required as described in 2.3.A.
3. All control panels fed by 120VAC shall have a main DIN rail mounted circuit breaker.
4. The following types of loads shall be individually fed by circuit breakers:
   a. Panel mounted receptacles.
   b. UPS equipment.
   c. DC Power Supplies.
5. Circuit breakers shall be sized according to the loads they are powering.
6. Acceptable Manufacturers
   a. Square D.
   b. Cutler Hammer.
   c. Or Approved Equal.

I. Motor Controllers

1. All motor controllers shall meet the requirements of Division 26.

J. Uninterruptible Power Supplies (UPS)

1. All UPS equipment shall meet the requirements of Section 263353.
2. UPS equipment intended to be installed in control panels shall meet the following criteria:
   a. The UPS shall be UL listed and shall maintain the UL listing of the control apnel.
   b. The UPS shall be properly mounted to withstand vibration and seismic requirements for the project.
   c. The UPS shall be sized for 200% of the calculated panel load.
   d. The UPS shall have a minimum backup time of 30 minutes unless specifically stated as otherwise on the Contract Drawings.
   e. For PLC panels, the UPS shall be equipped with dry contacts for monitoring the UPS for any alarm conditions and low battery.
3. Where specifically shown on the Contract Drawings, an industrial DC UPS may be used as backup power for the control panel. This will typically be the case where all critical loads are at 24VDC.
4. Unless indicated as otherwise on the Contract Drawings, the UPS equipment shall be the line-interative type and operate at 120VAC.
5. UPS equipment shall provide surge, EMI
6. Acceptable Manufacturers
   a. Powerware 5000 series (line-interactive) or 9000 series (online).
   b. Sola SDU Series (24VDC UPS).
   c. Or Approved Equal.

K. Power Supplies

1. Provide 24VDC Power Supplies or other DC voltages as required for the application.
2. All power supplies shall be oversized for a minimum 150% of the calculated load.
3. All power supplies shall be properly protected by a DIN rail mount circuit breaker whose trip rating is per the manufacturer's recommendation.
4. All power supplies shall have a set of dry contacts that indicate when the power supply is operating normally.

5. Where shown on the Contract Drawings, provide redundant power supplies and corresponding diodes.
6. Power supplies shall meet the following criteria:
    a. Input Voltage: 100 to 240VAC.
    b. Output Voltage: ±1% of rated output.
    c. Operating Temperature: 0°C to 60°C.
    d. Built in transient surge protection.
    e. DIN rail mountable, metal housing.
7. Acceptable Manufacturers
    a. Phoenix Contact Quint Series.
    b. Or Approved Equal.

L. Signal Isolators/Converters

1. Furnish signal isolators as required that optically isolate the input signal from the output signal. If output signal is to be a different type of signal than the output than the isolator shall convert the signal as required.
2. Isolators output shall be adjustable for zero and span.
3. If input signal is part of a Hart system, the isolator shall be made specifically to pass on the Hart signal.
4. Acceptable Manufacturers
    a. Phoenix Contact.
    b. Action Instruments.
    c. Or Approved Equal.

M. Intrinsically Safe Barriers

1. Provide intrinsically safe barriers wherever analog or discrete input signals are coming from classified areas.
2. Intrinsically safe barriers shall be located in their own enclosure whose assembly is UL rated. Install the barriers and field wiring as per the requirements of NEC and the manufacturer's installation guidelines.
3. If input signal is part of a Hart system, the isolator shall be made specifically to pass on the Hart signal.
4. Acceptable Manufacturers
    a. Phoenix Contact.
    b. Pepperl Fuchs.
    c. Or Approved Equal.

N. Relays

1. Provide relays whose contact ratings are sized according to the load requirements and size of the protection device associated with the circuit in which the contacts are wired. As a minimum contact ratings shall be 10A resistive up to 250VAC.
2. Provide relays whose coil voltage is as required by the application.
3. Relays with DC rated coils shall have a freewheel diode installed across the coil.
4. Relays with AC rated coils shall have a surge suppressor installed across the coil.
5. Relays shall have based with relays which plug into the base. Bases shall have screw-type connections.
6. Relays shall have an LED indicating when the relay is coil is energized.

7. Provide enough relay contacts for each relay as required by the application. If the number of contacts required exceeds the number of contacts on the relay, provide additional relay(s) to provide enough sets of contacts.
8. Acceptable Manufacturers
    a. Idec R Series.
    b. Allen-Bradley 700H Series.
    c. Or Approved Equal.

O. Time Delay Relays

1. Provide time delay relays to control on and off delay times as required by the application.
2. Time delay relays shall meet the requirements of relays as listed above with the following additional requirements:
    a. Time delay shall be adjustable from 0.1 seconds to 600 hours.
    b. Timers shall be multi-function and shall be capable of providing on-delay, off-delay, cycle timing and one-shot type timing control.
3. Acceptable Manufacturers
    a. Idec RTE Series.
    b. Phoenix Contact ETD Series.
    c. Or Approved Equal.

P. Panel HVAC Components

1. Provide heating, ventilation, and air conditioning, devices in order to maintain all components within the control panel within the acceptable range as specified in Section 409000.
2. HVAC equipment shall maintain the required NEMA rating for the control panel assembly.
3. Externally mounted HVAC equipment (such as air-to-air exchangers or air conditioners) shall be housed in an enclosure whose material matches the material of the control panel. Where in corrosive environments, all components that will come in contact with outside air shall be corrosion resistant for that environment.
4. All HVAC equipment shall be UL rated. For equipment mounted on the control panel, the equipment shall have a corresponding NEMA rating.
5. Provide power as required for the HVAC equipment. HVAC loads shall be included in feeder and control power transformer sizing calculations.
6. Panel Heating
    a. Heating shall be provided when ambient temperatures are expected to fall below the allowed range as specified in Section 409000. As a minimum, heating shall be sized to keep the panel temperature at or above 50°F.
    b. Except for small anti-condensating heaters, heating equipment shall have fans which distribute the heat throughout the enclosure. Heaters shall be installed according to the manufacturer's installation instructions. Provide enough space between the heating equipment and other components such that the other components to not experience abnormally high temperatures.
    c. Provide anti-condensating heaters for all outdoor enclosures which house electronics, instrumentation and/or motor controllers.
    d. All heaters shall be thermostatically controlled by a DIN rail mounted thermostat.
    e. Acceptable Manufacturers
        1) Hoffman.
        2) Or Approved Equal.
7. Panel Ventilation

a. Where ventilation is determined to maintain the control panel's maximum temperature as required by Section 409000, the following requirements shall be adhered to:
   1) Ventilation shall maintain the required NEMA rating for the control panel assembly.
   2) For indoor, non-corrosive locations (panels with NEMA 12 ratings), conventional ventilation with fans and vents may be used.
   3) For corrosive or outdoor locations, side or top mounted air-to-air heat exchangers shall be used.

b. The fan(s) and corresponding vents or air-to-air heat exchangers shall be properly sized and located to move enough air through the panel to remove the generated heat as well as allow air flow across all heat generating equipment.

c. All ventilation shall be thermostatically controlled by a DIN rail mounted thermostat.

d. Acceptable Manufacturers
   1) Hoffman.
   2) Pfannenberg.
   3) Or Approved Equal.

8. Panel Air Conditioning
   a. Where it is deemed necessary to air condition a control panel to maintain the control panel's maximum temperature as required by Section 409000, the following requirements shall be adhered to:
      1) Air conditioners shall be side or top mounted and shall be sized based upon the heat generated within the control panel, the maximum outside air temperature, and the amount of sunlight the control panel may be exposed to. Air conditioners shall be oversized by a safety factor of 25%.
      2) Air conditioners shall be thermostatically controlled by a DIN rail mounted thermostat. In addition, the air conditioner shall turn off if the panel door(s) are not closed.
   b. Acceptable Manufacturers
      1) Hoffman.
      2) Pfannenberg.
      3) Thermal Edge.
      4) Kooltronics.

PART 3 - EXECUTION

3.1 FACTORY ACCEPTANCE TESTING

1. All control panels shall be factory acceptance tested (FAT) as required by Section 409000.

3.2 INSTALLATION

A. All control panels shall be installed according to the requirements of Section 409000.

B. All control panels shall be installed so that their surfaces are plumb and level.

C. All control panels shall be properly mounted so as to withstand the seismic requirements for the Site. Anchor panels securely to the wall or floor at each corner as a minimum.

D. Control panels shall have been designed according to locations for conduit entry. Floor mounted panels in electrical rooms shall have cutouts in the bottom of the enclosure that were cutout by the panel shop. All conduit holes shall be cut in the field.

E. Field wiring
   1. Wires that are terminated in control panels after permanent panel installation are deemed as field wires. Field wiring shall be installed in the allocated wire ducts and shall be properly labeled and terminated.
   2. All field wires shall be long enough to reach each corner of the enclosure. Neatly coil up extra wire length at the bottom of the enclosure. Do not use the wire ducts for storing extra wire length.

3.3 FIELD QUALITY CONTROL

A. Refer to Section 409000.

END OF SECTION 409513

SECTION 432010 - PUMPS, GENERAL

PART 1 - GENERAL

1.1 THE REQUIREMENT

A. The Contractor shall provide all pumps and pumping appurtenances, complete and operable, in accordance with the Contract Documents.

B. The provisions of this Section shall apply to all pumps and pumping equipment except where otherwise indicated in the Contract Documents.

C. Unit Responsibility: A single manufacturer shall be made responsible for furnishing the Work and for coordination of design, assembly, testing, and installation of the Work of each pump Section; however, the Contractor shall be responsible to the Owner for compliance with the requirements of each pump Section. Unless otherwise indicated, the single Manufacturer shall be the Manufacturer of the pump.

D. Single Manufacturer: Where two or more pump systems of the same type or size are required, the pumps shall all be produced by the same Manufacturer.

1.2 CONTRACTOR SUBMITTALS

A. General: Submittals shall be furnished in accordance with Section 013300 – Contractor Submittals.

B. Shop Drawings: Shop drawings shall contain the following information:
1. Pump name, identification number, and specification Section number.
2. Performance data curves showing head, capacity, horsepower demand, NPSH required, and pump efficiency over the entire operating range of the pump. The equipment Manufacturer shall indicate separately the head, capacity, horsepower demand, overall efficiency, and minimum submergence required at the design flow conditions and the maximum and minimum flow conditions. A family of performance curves at intervals of 100 rpm from minimum speed to maximum speed shall be provided for each centrifugal pump equipped with a variable frequency drive.
3. The Contractor shall require the Manufacturer to indicate on the performance curves the limits recommended for stable operation without surge, without cavitation, and without vibration (except vibration within specified allowable limits). The stable operating range shall be as wide as possible based on actual hydraulic and mechanical measurements taken during the factory performance tests of the pumps.
4. Assembly and installation drawings including shaft size, seal, coupling, bearings, anchor bolt plan, part nomenclature, material list, outline dimensions, and shipping weights.
5. Data, in accordance with Division 26 for the electric motor proposed for each pump.
6. Elevation of proposed Local Control Panel showing panel-mounted devices, details of enclosure type, single line diagram of power distribution, and current draw of panel, and list of all terminals required to receive inputs or to transmit outputs from the Local Control Panel.
7. Wiring diagram of field connections with identification of terminations between Local Control Panels, junction terminal boxes, and equipment items.
8. Complete electrical schematic diagram.

C. Operation and Maintenance Manual: The Manual shall contain the required information for each pump Section.

D. Anchorage: The manufacturer shall provide anchor bolt design calculations in accordance with the latest edition of CBC, stamped and signed by a licensed professional engineer in the State of California.

E. Spare Parts List: A Spare Parts List shall contain the required information for each pump Section.

F. Factory Test Data: Signed, dated, and certified factory test data for each pump system which requires factory testing, submitted before shipment of equipment.

G. Certifications
   1. Manufacturer's certification of proper installation.
   2. Contractor's certification of satisfactory field testing.

1.3 QUALITY ASSURANCE

A. Factory Testing: The following tests shall be conducted on each indicated pump system:
   1. Motors: All motors of sizes 100 hp and larger shall be assembled, tested, and certified at the motor factory and the working clearances checked to insure that all parts are properly fitted. The tests shall be in accordance with ANSI/IEEE 112 - Test Procedure for Polyphase Induction Motors and Generators, and ANSI/IEEE 115 - Test Procedure for Synchronous Machines, including heat run and efficiency tests. All computations shall be recorded and certified and dated copies of the test results shall be furnished.
   2. Pump Systems: All centrifugal pump systems 100 hp and larger shall be tested at the pump factory in accordance with the Test Code for Centrifugal Pumps of the Standards of the Hydraulic Institute, Inc. Tests shall be performed using the complete pump system to be furnished, including the motor.
   3. For motors smaller than 100 hp, the Manufacturer's certified test motor shall be acceptable. Testing of prototype models will not be acceptable. The following minimum test data shall be submitted:
      a. Hydrostatic test data
      b. A minimum of five hydraulic test readings between shutoff head and 25 percent beyond the maximum indicated capacity, recorded on data sheets as defined by the Hydraulic Institute.
      c. Pump curves showing head, flow, bhp, efficiency, and NPSH requirements.
      d. Certification that the pump horsepower demand did not exceed the rated motor hp beyond the 1.0 service rating at any point on the curve.
   4. Factory Witnessed Tests: All pumps, variable speed drives, and motors, 150 hp and larger shall be factory-tested as complete assembled systems and may be witnessed by the Owner and Engineer. The use of one of each type project motor and variable frequency drive for testing all pumps shall be acceptable. The Contractor shall give the Engineer a minimum of 4 weeks notification prior to the test. All costs for Owner and Engineer expenses shall be borne by the Contractor and shall be included in the bid price. Such costs shall include travel and subsistence for two people excluding salaries. Test results shall be submitted to the Engineer and no equipment shall be shipped until the test data have been approved by the Engineer.

B. Warranty: Unless otherwise specified, each pump shall be supplied with manufacturer’s standard warranty of one (1) year from substantial completion.

PART 2 - PRODUCTS

2.1 GENERAL

A. Compliance with the requirements of the individual pump Sections may necessitate modifications to the Manufacturer's standard equipment.

B. Performance Curves: All centrifugal pumps shall have a continuously rising curve. In no case shall the required horsepower at any point on the performance curve exceed the rated horsepower of the motor or engine, or encroach on the service factor.

C. No cavitation shall be allowed in pumps operating within the stable operating range for the specified operating conditions. For the purposes of this provision, cavitation shall be recognized and accepted as being present in a pumping unit if cavitation noise can be perceived either by the human ear or by acoustic instruments or devices. The presence or absence of cavitation noise shall be verified by the Owner during both the factory performance tests of the pumps and during operation of the pumps up to the end of the warranty period. To assist in revealing potential cavititation during the factory performance tests, in addition to all other required tests, the Manufacturer shall force the pumps to operate at the specified minimum net positive suction head available for each of the following conditions: minimum flow rate, design flow rate and head, and maximum flow rate.

D. All components of each pump system provided under the pump Sections shall be entirely compatible. Each unit of pumping equipment shall incorporate all basic mechanisms, couplings, electric motors, variable frequency controls if required, necessary mountings, and appurtenances.

2.2 MATERIALS OF CONSTRUCTION

A. All materials shall be suitable for the intended application; materials not specified shall be high-grade, standard commercial quality, free from all defects and imperfection 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 pump casings and bowls shall be of austenitic ductile iron, conforming to ASTM A 439 - Specification for Austenitic Ductile Iron Castings, or equal.
   2. Bronze pump impellers shall conform to ASTM B 62 - Specification for Composition Bronze or Ounce Metal Castings, or B 584 - Specification for Copper Alloy Sand Castings for General Applications, where dezincification does not exist.
   3. Stainless steel pump shafts shall be Type 416 or 316. Miscellaneous stainless steel parts shall be of Type 316.
   4. All anchor bolts, nuts, and washers that are not buried or submerged shall be hot-dip galvanized, unless otherwise specified in individual pump Sections. Buried or submerged bolts, nuts, and washers shall be stainless steel in accordance with Section 055000 – Metal Fabrications.

2.3 PUMP COMPONENTS

A. Flanges: Suction and discharge flanges shall conform to ANSI/ASME B16.1 - Cast Iron Pipe Flanges and Flanged Fittings, Class 25, 125, 250, and 800 or B16.5 - Pipe Flanges and Flanged Fittings Dimensions.

B. Lubrication: Vertical pump shafts of clean water pumps shall be product water-lubricated, unless otherwise specified. Deep-well pumps and pumps with dry barrels shall have water- or oil-lubricated bearings and seals and enclosed lineshafts. Pumps for other process fluids shall be lubricated as indicated.

C. Handholes: Handholes on pump casings shall be shaped to follow the contours of the casing to avoid any obstructions in the water passage.

D. Vortex Suppressors: Vertical pumps with marginal submergence shall be provided with vortex suppressors.

E. Drains: All gland seals, air valves, cooling water drains, and drains from variable frequency drive equipment shall be piped to the nearest floor sink, or drain, with galvanized steel pipe or copper tube, properly supported with brackets.

F. Grease Lubrication: For all vertical propeller, mixed-flow, and turbine pumps, other than deep well pumps, of bowl sizes 10-inches and larger, the Contractor shall provide a stainless steel tube attached to the column for grease lubrication of the bottom bearing.

G. Stuffing Boxes: Where stuffing boxes are indicated for the pump seal, they shall be of the best quality, using the Manufacturer's suggested materials best suited for the specific application. For drainage and liquids containing sediments, the seals shall be fresh-water flushed, using lantern rings.

1. Unless otherwise specified, the packing material shall be interlaced Teflon braiding, containing 50 percent ultrafine graphite impregnation to satisfy the following:
    a. Shaft speeds - up to 2500 rpm
    b. Temperature - up to 500 degrees F
    c. pH range - 0 to 14.
2. If fresh water is not available, the seal shall be flushed with product water cleaned by a solids separator as manufactured by John Crane Co., Lakos (Claude Laval Corp.), or equal.

H. Mechanical Seals: Mechanical seals shall be fresh water-flushed unless indicated otherwise; in which case product water cleaned by a solids separator as above shall be used. Mechanical seals shall be as manufactured by the following, or equal:

Type	Manufacturer
Wastewater Pumps	Double seals: John Crane Type L Double; Borg-Warner Type L Double; Chesterton
Abrasives, Grit, or Lime Slurry Pumps	Double seals: John Crane Type I (hard faces); Borg-Warner Type L (hard faces); Chesterton
Chemicals or Corrosive Liquid Pumps	Single seals: John Crane Type 8-1, 9; Borg-Warner Type Q, QB; Chesterton
Water Pumps Hot and Cold	Single seals: John Crane, Type I, 21; Borg-Warner Type L; Chesterton

I. Where indicated, a buffer fluid must be circulated a minimum 20 psi above discharge pressure, or as required by the Manufacturer, in order to maintain reliable seal performance.

J. Mechanical seals for all services other than chemicals and corrosives shall be equipped with nonclogging, single coil springs and nonsliding, internal, secondary elastomers. Metal parts shall be Type 316 stainless steel, Alloy 20, or Hastelloy B or C.

2.4 PUMP APPURTENANCES

A. Nameplates: Each pump shall be equipped with a stainless steel nameplate indicating serial numbers, rated head and flow, impeller size, pump speed, and Manufacturer's name and model number. Dimension and flow information shall be in metric units, followed by English units in parentheses.

B. Solenoid Valves: The pump Manufacturer shall provide solenoid valves on the water or oil lubrication lines and on all cooling water lines. Solenoid valve electrical ratings shall be compatible with the motor control voltage.

C. Gauges: all pumps (except sample pumps, sump pumps, and hot water circulating pumps) shall be equipped with pressure gauges installed at pump discharge lines. Pump suction lines shall be provided with compound gauges. Gauges shall be located in a representative location, where not subject to shock or vibrations, in order to achieve true and accurate readings.
1. Where subject to shock or vibrations, the gauges shall be wall-mounted or attached to galvanized channel floor stands and connected by means of flexible connectors.
2. Pressure and compound gauges shall be provided in accordance with Section 40 73 13 – Pressure Gauges.

D. Spare Parts: One full set of all recommended spare parts shall be provided with each set of pumps.

PART 3 - EXECUTION

3.1 SERVICES OF MANUFACTURER

A. Inspection, Startup, and Field Adjustment: Where required by the individual pump Sections, an authorized service representative of the Manufacturer shall visit the site for the number of days indicated in those Sections to witness the following and to certify in writing that the equipment and controls have been properly installed, aligned, lubricated, adjusted, 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 to ensure that the equipment installation and operation comply with the specified requirements.

B. Instruction of the Owner's Personnel
1. Where required by the individual pump Sections, an authorized training representative of the Manufacturer shall visit the site for the 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 for the representative shall be submitted.
3. Training shall be scheduled a minimum of three weeks in advance of the first session.
4. Proposed training material and a detailed outline of each lesson shall be submitted for review. Comments shall be incorporated into the material.
5. The training materials shall remain with the trainees.
6. The Owner may videotape the training for later use with the Owner personnel.

3.2 INSTALLATION

A. General: Pumping equipment shall be installed in accordance with the Manufacturer's written recommendations.

B. Alignment: All equipment shall be field tested to verify proper alignment, operation as specified, and freedom from binding, scraping, vibration, shaft runout, or other defects. Pump 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. Lubricants: The Contractor shall provide the necessary oil and grease for initial operation.

3.3 PROTECTIVE COATING

A. Materials and equipment shall be coated as required in Section 098000 – Protective Coatings.

3.4 FIELD TESTS

A. Where required by the individual pump Sections, each pump system shall be field tested after installation to demonstrate satisfactory operation without excessive noise, vibration, cavitation, or overheating of bearings.

B. The following field testing shall be conducted:
1. Startup, check, and operate the pump system over its entire speed range. Vibration shall be within the amplitude limits recommended by the Hydraulic Institute Standards at a minimum of four pumping conditions defined by the Engineer.
2. Obtain concurrent readings of motor voltage, amperage, pump suction head, and pump discharge head for at least four pumping conditions at each pump rotational speed. Check each power lead to the motor for proper current balance.
3. Determine bearing temperatures by contact type thermometer. A run time of at least 20 minutes shall precede this test, unless insufficient liquid volume is available.
4. Electrical and instrumentation tests shall conform to the requirements of the Sections under which that equipment is indicated.

C. Field testing will be witnessed by the Engineer. The Contractor shall furnish 5 days advance notice of field testing.

D. In the event any pumping system fails to meet the test requirements, it shall be modified and retested as above until it satisfies the requirements.

E. After each pumping system has satisfied the requirements, the Contractor shall certify in writing that it has been satisfactorily tested and that all final adjustments have been made. Certification shall include the date of the field tests, a listing of all persons present during the tests, and the test data.

F. The Contractor shall bear all costs of field tests, including related services of the Manufacturer's representative, except for power and water which the Owner will bear. If available, the Owner’s operating personnel will provide assistance in field testing.

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SECTION 432513 – VERTICAL WET WELL RECIRCULATOR CHOPPER PUMPS

PART 1 - GENERAL

1.1 SCOPE OF SUPPLY

The vendor shall furnish _2_ centrifugal, wet pit vertical chopper pump and all appurtenances as specified in this section. The wet-well pump shall be specifically designed to pump waste solids at heavy consistencies without plugging or dewatering of the solids. Materials shall be chopped and conditioned by the pump as an integral part of the pumping action. The pump must have demonstrated the ability to chop through and pump high concentrations of solids such as plastics, heavy rags, grease and hair balls, wood, paper products and stringy materials without plugging, both in tests and field applications.

1.2 RELATED SECTIONS

A. Common Motor Requirements for Equipment, Section 220513

B. Pump, General, Section 432010.

1.3 CONDITIONS OF OPERATION

A. Each pump shall be capable of pumping at the hydraulic conditions shown in the pump schedule or on the drawings.

1.4 SUBMITTALS

A. Complete assembly, foundation support, and installation drawings, together with detailed specifications and data covering pumps, motors, material used, parts, devices and other accessories forming a part of the equipment furnished shall be submitted for approval in accordance with the procedure set forth in the General Conditions.

B. Data and specifications for the equipment shall include, but shall not be limited to the following:

Setting plans. Setting plans shall include:

a. Anchor bolt layout
b. Anchor bolt dimensions.
c. Outline dimensions and weights of pumps, bases, motors, and control enclosures.

C. Pumps. Data and drawings shall include:

1. Manufacturer, type and model number.
2. Assembly drawing, nomenclature and material list, O & M manual, and parts list.
3. Type, manufacturer, model numbers, location and spacing of bearings.
4. Impeller type, diameter, thru-let dimensions, sphere size, number of vanes and identification number.
5. Complete motor performance data including: rating, voltage/phase/frequency; design type; service factor; insulation class; motor pole number; actual rotation speed when combined

with the specified pumps; current, power factor and active input power (KW) as a continuous function of shaft power from no load to at least 115 percent load; start (max. inrush) current; locked rotor current; NEC code letter; and motor torque as a continuous function through the motor start cycle from no rotation to synchronous speed.

6. Complete performance test curve(s) showing full range (shutoff to run-out) head vs. capacity, NPSHR, hydraulic efficiency, motor active (KW) input power, motor total (KVA) input power (based on measured current and voltage), and shaft power (BHP). VFD pump curves shall be provided where pumps are indicated to operate on VFDs.
7. Location and description of Service Centers and spare parts stock.
8. Warranty for the proposed equipment.

D. The manufacturer shall indicate, by arrows to points on the Q/H curves, limits recommended for stable operation, between which the pumps are to be operated to prevent surging, cavitation, and vibration. The stable operating range shall be as large as possible, and shall be based on actual hydraulic and mechanical characteristics of the units and shall meet the hydraulic performance requirements of the proposed system.

E. Anchorage: The manufacturer shall provide anchor bolt design calculations in accordance with the latest edition of CBC, stamped and signed by a licensed professional engineer in the State of California.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. The following are acceptable:

1. Vaughan Co., Inc. model V3LR (Basis of Design)
2. Or Approved Equal

B. A manufacturer's being named in this specification notwithstanding, all equipment approved for this project shall meet or exceed all performance, service, and warranty requirements of this specification. Standard product must be modified, if required, for compliance. Manufacturer shall have installations of like or similar application with a minimum of 5 years' service for this pump size.

2.4 TEMPERATURE PROTECTION

A. Each pump motor stator shall incorporate three thermal switches, one per stator phase winding and be connected in series, to monitor the temperature of the motor.

B. Should the thermal switches open, the motor shall stop and activate an alarm. A float switch shall be installed in the seal leakage chamber and will activate if leakage into the chamber reaches 50% chamber capacity, signaling the need to schedule an inspection.

C. The thermal switches and float switch shall be connected to a Mini CAS control and status monitoring unit. The Mini CAS unit shall be designed to be mounted in the pump control panel.

D. Pumps shall be rated by a national testing Laboratory for use in Class 1 Div 1 Group C & D locations and rated Explosion-Proof .

2.5 SEAL LEAKAGE MONITORING

A. Furnish a monitoring system to signal seal leakage.

B. Provide a sensor in the motor's stator cavity which allows a control panel mounted relay to indicate leakage into the motor.

PART 3 - FABRICATION

3.1 GENERAL

A. The pumps shall be suitable for pumping raw, municipal sewage (2 ¾" min. solids) and shall be designed and fully guaranteed for this use.

B. The fluid temperature range shall be from 40 degrees to 115 degrees F.

3.2 SERVICE CONDITIONS

A. The pumps specified in this section will pump using the following design flow criteria:

1. GPM: _20_ TDH: _21.66 FT / 13.66FT_
2. GPM: _50_ TDH: _26.40 FT / 18.44FT_

3.3 PUMP CONSTRUCTION

A. Casing: Shall be of volute or semi-volute design, spiraling outward to the ANSI CL 125 flanged discharge. Casing shall be cast ductile iron with all water passages to be smooth, and free of blowholes and imperfections for good flow characteristics. Casing shall include a replaceable Rockwell C60 steel cutter adjustable for clearance to cut against the rotating impeller pump-out vanes for removing fiber and debris from behind the impeller.

B. Impeller: Shall be semi-open type with pump out vanes to reduce seal area pressure. Chopping of materials shall be accomplished by the action of the cupped and sharpened leading edges of the impeller blades moving across the cutter bar at the intake openings, with a maximum set clearance between the impeller and cutter bar of 0.015-0.025" cold. Impeller shall be cast steel heat treated to minimum Rockwell C60 and dynamically balanced. The impeller shall be keyed to the shaft and shall have no axial adjustments and no set screws. Pumps with open type impellers or impellers without modified pump out vanes to shear against the upper cutter shall not be acceptable.

C. Cutter Bar: Shall be recessed into the pump bowl and shall contain at least 2 shear bars extending diametrically across the intake opening to within 0.010-0.030" of the rotating cutter nut tooth, for the purpose of preventing intake opening blockage and wrapping of debris at the shaft area. Cutter bar shall be steel heat-treated to minimum Rockwell C60. Chopper pumps utilizing individually mounted shear bars shall not be acceptable.

D. Cutter Nut: The impeller shall be secured to the shaft using a cutter nut, designed to cut stringy materials and prevent binding using a raised, rotating cutter tooth. The cutter nut shall be cast steel heat treated to minimum Rockwell C60. Chopper pumps which do not have the ability to cut debris from the pump suction shall not be acceptable.

E. Upper Cutter: Shall be threaded into the casing behind the impeller, designed to cut against the pump-out vanes and the impeller hub, reducing and removing stringy materials from the mechanical seal area. Upper cutter shall be cast steel heat treated to minimum Rockwell C60. The upper cutter teeth are positioned as closely as possible to the center of shaft rotation to minimize cutting torque and nuisance motor tripping. The ratio of upper cutter cutting diameter to shaft diameter in the upper cutter area of the pump shall be 3.0 or less.

F. Pump Shafting: Lower stub shall be heat treated steel. Upper shaft extension shall be turned, ground and polished. The shaft column shall be minimum 4" O.D. precision steel tubing welded to steel flanges and machined with piloted bearing fits for concentricity of all components. All support column tubes shall be leak tested. Distance between shaft bearings shall not exceed critical speed dimensions.

G. Pump Shaft Bearings: Shall be oil bath lubricated by ISO. 46 hydraulic oil, except for the top bearing, which shall be greased packed. The bearings shall have a minimum L-10 rated life of 100,000 hours at any acceptable operating point on the pump performance curve. Shaft thrust shall be taken up by either angular contact ball bearings or tapered roller bearings, which bear against a machined shoulder on one side and the seal sleeve on the other side. Overhang from the centerline of the lower thrust bearing to the seal faces shall be a maximum of 1.7", with a mechanical seal to isolate the bearings from the pumped media.

H. Mechanical Seal: The mechanical seal is to be manufactured and warranted by the pump manufacturer. The mechanical seal shall be located immediately behind the impeller hub to eliminate the stuffing box and maximize the flushing available from the impeller pumpout vanes. The seal shall be a cartridge-type mechanical seal with Viton O-rings and silicon carbide or tungsten carbide faces. This cartridge seal shall be pre-assembled and pre-tested so that no seal settings or adjustments are required from the installer. Any springs used to push the seal faces together must be shielded from the fluid to be pumped. The cartridge shall also include a 17-4PH, heat-treated seal sleeve and ductile iron seal housing.

I. Automatic Oil Level Monitor: Shall be located above the mounting plate and be fitted with an internal oil level switch to detect oil level and shut off the motor in event of low oil level. A relay shall be included for mounting in the motor control panel.

J. Pump Discharge Pipe: Shall be _" Sch. 40 steel pipe mounted vertically through a fabricated steel deck plate with the ANSI CL 150 discharge flange and a discharge pressure tap located above the deck plate.

K. Shaft Coupling: Shall be T.B. Woods Sureflex elastomeric type with a minimum 1.5 service factor based on the drive rated horsepower and shall be protected with guards meeting OSHA requirements.

L. Motor Stool: Shall be a fabricated steel weldment machined with piloted fits to positively align the C-flanged motor and pump shaft, with no adjustments.

M. Pump Deck Plate: Shall be fabricated steel, 1/2" minimum thickness, and shall include lifting lugs and anchor bolt holes.

N. Stainless Steel Nameplate: Shall be attached to the deck plate giving the manufacturer's model and serial number, rated capacity, head, speed and all pertinent data

3.4 RECIRCULATION SYSTEM

A. Recirculation Nozzle Assembly: The pump shall be fitted with a recirculation nozzle assembly to permit recirculation of the pit contents prior to discharge. The recirculation nozzle shall be adjustable minimum 180 degrees horizontally and 45 degrees vertically. A valve assembly shall be connected to the pump discharge to adjust pump flow either to the nozzle or the pump discharge flange. Valve shall be cast ductile iron, with CD4MCu stainless steel valve disc and ANSI CL 125 flanged recirculation and discharge flange. The operating levers shall be located above at a mounting plate for easy access.

B. Automatic Valve Actuator: An electrically operated valve actuator shall position the valve for pumpout or mixed operation. A ball screw linear actuator shall be used to provide valve positioning. Unit shall operate on 110V or 220V AC, single-phase power with 25% duty cycle, and shall be capable of producing 500 lbs. of actuation force, with a freewheeling feature to prevent overtravel at the end of stroke. External 0-30 second timers, housed in a separate control unit (by others), are required to determine valve position. A capacitor for single phase-motor starting shall be included in the design. All components shall be housed in an enclosure suitable for outdoor operation.

3.5 SURFACE PREPARATION

Exterior surfaces shall be sandblasted and two coats of Tnemec Series 27WB epoxy applied at 5 MDFT for a total minimum finish of 10 MDFT. (Except Motor)

3.6 ANCHOR BOLTS

A. Equipment manufacturer shall furnish all anchor bolts of ample size and strength required to securely anchor each item of equipment. Anchor bolts, hex nuts, and washers shall be # T-316 stainless steel unless noted otherwise. Anchor bolts shall be threaded rods with washers and nuts embedded. Expansion-type anchors will not be acceptable. Anchor bolt design shall be completed by a professional engineer licensed in the State of California and shall be included in the submittal.

B. Anchor bolts shall be set by the CONTRACTOR. Equipment shall be placed on the foundations, leveled, shimmed, bolted down, and grouted with a non-shrinking grout

PART 4 - EXECUTION

4.1 INSTALLATION

A. Installation in strict accordance with the MANUFACTURER'S instructions and recommendations in the locations shown on the Drawings. Installation shall include any alignment, anchoring or grouting required for proper installation. Additionally, installation shall include furnishing the required oil and grease for initial operation. The grades of oil and grease shall be in accordance with the MANUFACTURER'S recommendations. Anchor bolts shall be set in accordance with the MANUFACTURER'S recommendations.

B. Upon completion of the installation, the CONTRACTOR shall submit a certificate from the MANUFACTURER stating that the installation of the equipment is satisfactory, that the equipment is ready for operation, and that the operating personnel have been suitably instructed in the operation, lubrication and are of each unit.

4.2 EQUIPMENT TESTING

A. General. Equipment shall be shop tested and field tested as specified hereinafter. All costs for the tests shall be borne by the Contractor. The Contractor shall submit the complete shop test procedures to the Engineer for approval at least 30 days prior to the shop test. In the event any equipment fails to meet the performance values set forth in this specification, the equipment shall be modified and re-tested or replaced with equipment that performs in accordance with this specification.

B. Shop Tests

1. Pumps and Motors. Each pump and motor shall be performance tested as specified hereinafter; all pumps shall be tested with motor cables to be supplied with the pumps. Three copies of certified test reports, including actual test records, shall be submitted and approved by the Engineer prior to shipment of the equipment.
2. The Contractor shall submit the complete pump test procedure, a diagram of the test setup showing location of instruments, a sample of the test stand log sheet, and calibration data of all instruments and measuring devices to be used by the manufacturer to the Engineer, for approval, prior to the pump tests.
3. Each pump shall be tested for performance at the factory to determine the head vs. capacity, motor total electrical power draw (KVA), and motor active electrical power draw (KW) for the full speed at which the pumps are specified and shown on a performance test curve, certified by a registered professional engineer, as continuous functions throughout the pump's performance range. Tests of models, prototypes or similar units will not be acceptable.
4. All tests shall be run in accordance with the test code for centrifugal pumps of the Standards of Hydraulic Institute, latest edition. The motor and cable on each pump shall be tested for moisture content or insulation defects. After the test, the pump cable end shall be fitted with a shrink-fit rubber boot to protect it from moisture or water.

C. Field Tests

1. Equipment shall be field tested as specified hereinafter. Field testing shall be composed of preliminary tests and acceptance tests as described in the Commissioning Section of the specifications (Division 1).
2. The Contractor shall provide the services of authorized equipment supplier's representatives to conduct all field tests for a minimum of two (2) days and two (2) trips.

END OF SECTION

SECTION 460753 – PACKAGE PLANT MBR

PART 1 - GENERAL

1.1 SCOPE OF SUPPLY

A. This Section specifies the requirements for the furnishing, installing, testing, training, startup and support of all process equipment required for a submerged membrane bioreactor package plant system for the treatment of wastewater.

B. The MBR System Supplier shall furnish and commission a fully functional and assembled packaged MBR System as describe in this specification, inclusive of all porch-mounted equipment, instrumentation, scope-specific piping and electrical systems, controls, tankage and integration.

C. The equipment shall be designed, constructed and installed in accordance with the best practice and methods, and shall operate satisfactorily when installed.

D. The MBR System Supplier shall provide engineering, design, installation supervision, commissioning support and digital services in support of the treatment system as described in this specification.

E. The Contractor shall furnish all labor, rigging, materials, and incidentals required for the installation of the MBR System in accordance with the installation instructions provided by the Supplier. Once installed, the MBR System shall be complete and operational with all control equipment and accessories as specified herein and described in the Contract Documents.

F. The Engineer is responsible for coordinating the Work with the services of others involved in the project. The Engineer shall decide as to the quality and acceptability of services and materials furnished and Work performed. All questions which may arise as to the interpretation of any or all Plans and Specifications and all questions as to the acceptable fulfillment of the Contract on the part of the Contractor and Suppliers shall be resolved by the Engineer.

G. The System Supplier must clearly identify in detail any and all exceptions to the Services and Scope of Supply described in this Specification.

1.2 RELATED SECTIONS

A. Common Motor Requirements for Equipment, Section 220513

B. Pump, General, Section 432010.

C. Electrical, Division 26

D. Process interconnections, Division 40

1.3 CONDITIONS OF OPERATION

A. This Section specifies the requirements for the furnishing, installing, testing, training, startup and support of all process equipment required for a submerged membrane bioreactor package plant system for the treatment of wastewater.

B. The MBR System Supplier shall furnish and commission a fully functional and assembled packaged MBR System as describe in this specification, inclusive of all porch-mounted equipment, instrumentation, scope-specific piping and electrical systems, controls, tankage and integration.

C. The equipment shall be designed, constructed and installed in accordance with the best practice and methods, and shall operate satisfactorily when installed.

D. The MBR System Supplier shall provide engineering, design, installation supervision, commissioning support and digital service s in support of the treatment system as described in this specification.

E. The Contractor shall furnish all labor, rigging, materials, and incidentals required for the installation of the MBR System in accordance with the installation instructions provided by the Supplier. Once installed, the MBR System shall be complete and operational with all control equipment and accessories as specified herein and described in the Contract Documents.

F. The Engineer is responsible for coordinating the Work with the services of others involved in the project. The Engineer shall decide as to the quality and acceptability of services and materials furnished and Work performed. All questions which may arise as to the interpretation of any or all Plans and Specifications and all questions as to the acceptable fulfillment of the Contract on the part of the Contractor and Suppliers shall be resolved by the Engineer.

G. The System Supplier must clearly identify in detail any and all exceptions to the Services and Scope of Supply described in this Specification.

1.4 SUBMITTALS

A. Project Submittal: The MBR System Supplier shall submit to the Engineer complete manufacturer's descriptive information for all equipment, instrumentation, and components in the Supplier's and the Membrane Manufacturer's Scope of Supply for the Engineer's approval prior to fabrication of equipment. The Supplier is to provide digital access to the submittals containing all submittal information organized by component, clearly marking options, models, materials, etc. Submittals are to be delivered within two (2) weeks from the Supplier's acceptance of a purchase order.

The Project Submittal shall contain the following:

1. System installation drawings, detailing system dimensions, materials, weights, locations of lifting lugs/points, and anchor bolt locations.

2. System mechanical layout drawings, detailing the number of membrane units, air and permeate piping distribution, piping supports, instrumentation and valves, and all other components comprising the MBR system. Drawings will detail information in plan and elevation/section views and include details as necessary to completely describe the installation requirements.

3. Tank seismic design calculations and coatings.

4. Manufacturer's literature for all equipment in MBR Suppliers scope of supply. Literature will include (as applicable):

a. Pump curves.
b. Blower curves.
c. Materials of construction.
d. Shop drawings showing all dimensions, sizes and locations of anchors.
e. Minimum, maximum, and design duty points (flow rates and pressures/TDH).
f. Unit performance and efficiency data.
g. Motor horsepower and voltage.
h. Complete wiring and control diagrams which show the point of connection for power supply.
    i. All project-specific installation data for used by the Contractor.

5. Where manufacturers' standard literature is submitted, it shall be clearly marked to indicate which features are to be furnished under this contract.

6. Process and Instrumentation Diagrams (P&IDs) showing all equipment and instrumentation which will be controlled by the MBR control system.

7. Process Flow Diagram.

8. Instrumentation literature and cut sheets, clearly identifying manufacturer, models, ranges, materials of construction, installation details, power supply voltage, wiring information.

9. Valve literature and cut sheets, clearly identifying manufacturer, models, Cv range, materials of construction, pressure rating, and dimensions.

10. Control panel drawings, detailing the interior and exterior layouts, components, panel dimensions, and panel materials of construction and NEMA rating.

11. Control panel component manufacturers' literature, clearly denoting model numbers of all PLC components, relays, terminal blocks, power supplies, buttons, switches, fuse blocks, etc.

12. Control panel wiring schematics.

13. Process control narrative

14. Warranty information, detailing membrane design fluxes for all seasonal flow conditions.

15. System start-up and test procedures.

B. Installation and Operations Manual (IOM): The MBR Supplier shall furnish an Installation and Operations Manual at least 2 weeks prior to the delivery of the Supplier's equipment on site. The IOM will include Supplier and manufacturer's manuals and drawings detailing dimensions, locations, wiring information, and any other information necessary to convey the correct assembly and installation of the MBR System components provided by the Supplier and Manufacturer. In addition to installation documents, the IOM shall include requirements for the Mechanical Inspection and a schedule of events for the System Commissioning. The Supplier is to provide digital access to the IOM containing all information organized by component.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. The following are acceptable:

1. Ovivo (Basis of Design)
2. Kubota
3. Suez
4. Or Approved Equal

A manufacturer's being named in this specification notwithstanding, all equipment approved for this project shall meet or exceed all performance, service, and warranty requirements of this specification. Standard product must be modified, if required, for compliance. Manufacturer shall have installations of like or similar application with a minimum of 5 years' service for this pump size. Should a manufacturer be selected which is not the basis of design, the contractor shall be responsible for changes to design drawings.

2.2 ENGINEERING AND DESIGN SERVICES

A. The MBR System Supplier will provide the following services for items in their Scope of Supply:

1. Biological Process Design Verification – The MBR Supplier shall support the Engineer in providing analysis and verification of the biological process design using EnviroSim BioWin wastewater modeling software and the customer's influent mass loading, diurnal flow curves, peak flow/loading numbers, and permit limits. The Suppler shall verify zone volumes; recycle rates, aerations requirements, chemical dosing requirements, and waste solids projections. The supplier shall provide a written report summarizing the modeling results.

2. Piping Hydraulic Analysis and Design – The MBR Supplier shall provide a detailed hydraulic analysis and mechanical design documentation of each process subsystem contained in the MBR system scope of supply. Using Pipe-Flo simulation software, subsystem piping designs shall be analyzed to verify flow distribution between membrane units, pump duty points and turn down, and flow control valve Cv and rangeability.

3. Equipment Sizing and Installation Details – The MBR Supplier shall verify duty points and turn-down, supply voltages, materials of construction, communications IO, equipment access and serviceability, area classifications, and pressure ratings for the MBR system's pumps, blowers, mixers, and valves.

4. Instrumentation Design – The MBR Supplier shall provide the Engineer with complete specification and documentation of all MBR system instrumentation. Each instrument's manufacturer, model, size, range, power, communications protocol, units, materials, connections, and area classification shall be documented in ISA Specification forms.

5. Controls Design – The MBR Supplier shall supply MBR system Process and Instrumentation Diagrams utilizing the Supplier's standard symbols and tagging schemes, MBR system control panel layout/fabrication details, and MBR system control panel wiring schematics. Additional controls documentation shall include PLC architecture diagrams, control panel BOM, panel IO arrangement, loop drawings, and a control narrative of the overall plant control scheme.

6. The Supplier will provide assistance to the Owner and Contractor and provide the information needed to coordinate the interface of the membrane bioreactor system into the overall facility.

7. The membrane bioreactor system piping shall be designed by the MBR Supplier to consider horizontal and vertical orientations and consider air entrainment, siphoning, air or vacuum binding, surging, and other transient fluid flow effects. Modifications to the P&ID supplied for this project may be considered based upon hydraulic considerations.

8. The membrane bioreactor system piping arrangement drawings shall be provided and detail the physical location and placement of valves and valve actuators and instrumentation. Provisions shall be made for the disassembly and maintenance of component equipment.

9. The membrane bioreactor system electrical arrangement drawings shall be provided and detail the physical location and placement of conduit runs, and the internal/external components of the PLC and MCP, electrical ratings, electrical schematics, network interconnect diagram and riser diagrams.

10. The MBR System Supplier shall assign a project engineer for the requirements of the project and for the duration from engineering through the correction period. The project engineer shall be on staff and be a single source of contact between the Supplier and the Owner as long as the project engineer is employed by the MBR System Supplier. The project engineer may only be changed by mutual agreement of the Owner and Supplier.

2.3 SYSTEM PERFORMANCE REQUIREMENTS

A. GENERAL

1. The biological treatment design shall be based on a biological nutrient removal process that will meet the effluent criteria and contain the following process steps:
   a. Aerobic/MBR
2. Process Redundancy
   a. A minimum of two Aerobic zones shall be provided.
   b. The aerobic zones shall meet 50% of MMF system performance requirements with one tank out of service indefinitely.
   c. Valves and/or Gates shall be provided to easily remove tanks from service while the remaining tanks maintain uninterrupted operation.
   d. To facilitate maintenance, all individual tanks or zones shall have a tank drain connection.

3. MBR Redundancy
   a. A minimum of two membrane zones shall be provided.
   b. The Membrane zones shall hydraulically meet 100% of MMF system performance requirements for 48 hours with one Membrane tank out of service.
   c. Valves and/or Gates shall be provided to easily remove tanks from service while the remaining tanks maintain uninterrupted operation.
   d. To facilitate maintenance, all individual tanks or zones shall have a tank drain connection.
   e. The MBR system shall be capable of handling the MMF flow listed in Table 2-1 for a period of 48 consecutive hours without loss of treatment efficiency or damage to the membranes or system.
   f. Polymer use or similar to improve membrane flux performance shall not be used to attain any redundancy performance requirements.
4. Minimum Flow Operation
   a. The MBR System shall be designed to meet effluent performance goals at a minimum sustainable flow of 2,000 gpd. The duration of the minimum flow may extend 30 days or more. To provide flexibility in turndown and provide the optimum in plant power and chemicals use, the MBR System Supplier shall incorporate:
      i. The ability to remove from service one membrane zone. The membrane zone shall be able to be drained and after cleaning be allowed to remain offline and dry for the extended period of time. Membranes must be naturally hydrophilic to remain stored in the basin without the use of wetting agents. No exceptions.
      ii. Valves and/or Gates shall be provided to easily remove tanks from service while the remaining tanks maintain uninterrupted operation.
      iii. To facilitate maintenance, all individual tanks or zones shall have a tank drain.
      iv. Rotary Lobe pumps with VFD control to provide maximum turn down. No exceptions.
      v. Blowers with VFD control designed to operate equipment within the required flow range. No exceptions
5. Headworks
   a. The Headworks equipment will be required to meet the membrane warranty of the supplied membrane technology and shall have the following performance parameters:
      i. Fine Screen shall have a maximum perforation opening of 2 mm or less as required to meet membrane warranty of the membrane technology supplied.
      ii. Maintain Coarse Suspended Solids (CSS) in the membrane basins at a maximum of 200 mg/L or less as recommended by the membrane technology.
      iii. Maintain a maximum level of Grit, as defined as recommended by the membrane technology.
   b. All headworks systems must accept a rescreen flow of 15% of the total system tank volume on a daily basis. Rescreen shall be taken from each membrane tank. No exception.
      i. Rotary lobe pump shall be installed. To provide maximum operational flexibility, pumps shall be controlled with VFDs. No exception.

6. Membrane Maintenance Clean, Recovery Clean or CIP Procedures
    a. Membrane Maintenance Clean, Recovery Cleans or CIP shall be fully automated and have the capability to be remotely operated. Semi-automatic or manual cleaning is not allowed. Membrane subunits shall be cleaned in place using any of three methods in order to maintain production capacity and meet performance requirements specified herein. The allowable frequency of listed cleaning methods shall be as follows:
        i. Backpulse or Backwash shall not exceed 8 per hour.
        ii. Maintenance Clean or CIP frequency shall not exceed 1 in 2 weeks.
        iii. Recovery Clean frequency shall not exceed 4/yr.
7. WAS
    a. WAS shall be removed as required to maintain a healthy biological process and to maintain MLSS level with the specified operational window.
    b. Wasting shall be fully automated and have the capability to be remotely operated. Semi-automatic or manual cleaning is not allowed. No exception.
    c. Rotary lobe pump shall be installed. To provide maximum flexibility pumps shall be controlled with VFDs. No Exception

B. The MBR System shall be configured to hydraulically equalize seasonal and diurnal flows shown in Table 2-1 and Table 2-2.

Table 2-1: Plant Hydraulic Flow Criteria

Parameter (Flows)	**Influent**		**Event Duration**	**Maximum Design Frequency[2]**	**Sequential Duration**
Minimum Daily Flow (MnDF)[1]	2,000	GPD	1 month	12/yr	Consecutive
Average Daily Flow (ADF)	23,000	GPD	1 month	12/yr	Consecutive
Maximum Month Flow (MMF)[1]	30,000	GPD	1 month	12/yr	Consecutive
Peak Daily Flow (PDF)	30,000	GPD	48 hours	8/yr	Non-Consecutive
Peak Hour Flow (PHF)[3]	50	GPM	24 m/hr	365 d/y	Non-Consecutive

Notes:
1. MMF and MnDF conditions are central to both biological and hydraulic designs.
2. Maximum Design Frequency is to provide sustainable operational flexibility indefinetly.
3. PHF, Maximum Instantaneous flow into the MBR system.

C. The MBR System shall be designed to accommodate the diurnal pattern indicated in Table 2-2. Flow will be equalized to provide consistent diurnal over 24 hours.

Table 2-2: Diurnal Profile Flow Ratio to (MMF)

Time	**Flow Ratio**
00:00 – 01:00	0.03
01:00 – 02:00	0.03
02:00 – 03:00	0.03
03:00 – 04:00	0.03
04:00 – 05:00	0.03
05:00 – 06:00	0.03
06:00 – 07:00	0.03
07:00 – 08:00	0.03

Time	**Flow Ratio**
08:00 – 09:00	0.03
09:00 – 10:00	0.03
10:00 – 11:00	0.03
11:00 – 12:00	0.03
12:00 – 13:00	0.03
13:00 – 14:00	0.03
14:00 – 15:00	0.03
15:00 – 16:00	0.03

Time	**Flow Ratio**
16:00 – 17:00	0.03
17:00 – 18:00	0.03
18:00 – 19:00	0.03
19:00 – 20:00	0.03
20:00 – 21:00	0.03
21:00 – 22:00	0.03
22:00 – 23:00	0.03
23:00 – 24:00	0.03

D. The MBR System shall be capable of treating raw wastewater at listed flows to the specified effluent criteria shown in Table 2-3.

Table 2-3: Plant Pollutant Loading and Effluent Criteria

Parameter	Influent[1,4,9]	Effluent[6]
$CBOD_5$	350 mg/L	<25 mg/L
TSS	350 mg/L	<25 mg/L[2]
TKN	49 mg/L	--
NH3	45 mg/L	--
TN	49 mg/L	<10 mg/L
TP	8 mg/L	--L
Akalinity[7]	300 mg/L	--
FOG[8]	700 mg/L	--

Parameter	Value[6]
Effluent Fecal Coliform	--
Effluent Turbidity	<1 NTU[3]
Effluent DO	--
Influent Min Temp	15 Deg C
Influent Max Temp	25 Deg C
Influent pH	6-8 SU

Notes:

1. Influent loading shall be within ± 10% of MMF design value.
2. Measured TSS shall be less than or equal to 10 mg/L on 9 of 10 consecutive samples and no sample shall exceed 15 mg/L.
3. Measured turbidity shall be less than or equal to .5 NTU on 9 of 10 consecutive samples and no sample shall exceed 1 NTU.
4. Influent shall be screened so that at least 85% of solids with any 2 dimensions greater than or equal to 3mm in length are removed.
5. Effluent limits are based on measurements using Standard Methods for the Examination of Water and Wastewater (Latest Edition).
6. Water hardness shall not exceed 300 mg/l as CaCO3.
7. FOG shall not exceed 20% of the system BOD.
8. No substances shall be placed in the system in quantities which are not biodegradable or toxic to the biological system.

E. Site Conditions
1. System location is outdoors.
   a. Ambient air temperatures shall be between 25°F and 110 °C.
   b. The supplier shall provide weatherization of equipment for operation in these conditions.
      i. All components subject to freezing must be protected with appropriate heat tracing.
      ii. Control panels shall include air conditioning units.
2. Maximum Lifting Height
   a. Maximum equipment and membrane lifting height is show on the drawings.
   b. The MBR supplier will provide a membrane lifting crane to remove membrane modules.
3. The elevation above sea level: 2,140 ft.
4. Seismic
   a. The Supplier shall provide documentation stating that the installed equipment anchorage can meet the following seismic criteria:
      i. Seismic Importance Factor: 1.5
      ii. Occupancy Category: II
      iii. Mapped Spectral Response Accelerations: SS = 125.8%, Sd = 44.4%
      iv. Spectral Response Coefficients: Sds = 83.9%, Sd1 = 46.1%.
      v. Seismic Design Category: D.
      vi. Component Anchorage Factors (Process Equipment): ap = 1.0, Rp = 2.5
5. System shall meet NFPA 820 standard for fire protection in wastewater treatment systems. -

Standard for Fire Protection in Wastewater Treatment and Collection Facilities. MBR System Supplier-provided equipment will be installed in areas that have NEC area classification with a Class 1, Group D, Division 1 envelope and a Class 1, Group D, Division 2 envelope. The Supplier shall provide equipment suitable for installation in these area's classification.

6. Membrane Integrity Testing
   a. Online membrane integrity testing shall be sufficient to detect a breach in a single membrane element or element connection.

2.4 SUBSYSTEM SCOPE OF SUPPLY

MBR System Supplier shall furnish the Subsystem Components listed below in accordance with the requirements of the project Specifications and Contract Documents.

A. SYSTEM CONFIGURATION
   1. The MBR System is to be a complete and functional, factory pre-assembled and factory tested package system for wastewater treatment utilizing activated sludge and submerged membranes for biological treatment and solids separation.
   2. The overall system configuration shall conform to the performance requirements and specifications.
   3. The overall system shall fit within the allocated area requirements.
   4. All equipment will be pre-assembled. All components shall be shipped factory pre-assembled and skid mounted as a complete plug and play package unit with steel tanks on-board unless otherwise noted.
   5. All on-board pumps irrespective of the service shall be of like type, make and model.
   6. All pumps and blowers shall have individual local disconnects and VFDs.
   7. All process critical pumps and blowers shall have an installed standby.
      a. Each piece of equipment shall be provided with shut off valves or mechanisms so that it may be isolated or by-passed, while still providing system operation to take place.
   8. The main system skid and tank components must be on-board and limited to a maximum of one (1) total complete assembly.
      a. Loose equipment supply or separate skid systems for the main system process equipment are not acceptable, unless noted by this specification otherwise.
      b. Any item noted as off-board or loose equipment supply is to be:
         i. Provided by the MBR Supplier.
         ii. The Contractor responsibility to provide and install anchors, supports, interconnecting piping, electrical and communications.

B. SYSTEM SUPPLY
   1. MBR System Supplier shall furnish the Components listed below in accordance with the requirements designated herein. Components listed as not required are not provided by the MBR Supplier and may be supplied by others only if necessary for a complete and functional system:
      a. System Base and Supplemental Tanks
         i. Tanks with integral equipment porches.
         ii. Backwash Tank
         iii. PLC, Motor Control Panel, HMI and SCADA, with Climate Control.

        iv. 110 VAC Transformer.
        v. Convenience outlets.
        vi. Porch lights.
        vii. Lot of pipe and electrical.
        viii. Weirs.
        ix. Equipment lifting crane.
        x. Heat Trace.
        xi. Access platforms with rails.
    b. Headworks
        i. 2 mm Fine Screen
        ii. Screen Conveyance.
        iii. Level Switch(s).
        iv. Rescreen
    c. Process Equipment and Instruments.
        i. Pre-Aeration(s).
            a. Fine Bubble Diffusers.
            b. DO Probes. 1 for each zone.
        ii. MBR Zone(s).
            a. Large Membrane Sub-unit(s).
            b. TSS Probe(s).
            c. Level Transmitter.
            d. Level Switches.
    d. Dry Mount Pumps and Instruments.
        i. Permeate Pumps.
            a. Installed standby
            b. Isolation valves.
            c. Gauges.
            d. Check valves.
            e. Sample port(s).
            f. Air extraction system.
            g. Anti-syphon shut-off.
            h. TMP measurement.
            i. Flow Meter
            j. Turbidity monitor(s)
        ii. WAS and Rescreen Pumps.
            a. Isolation valves.
            b. Gauges.
            c. Check valves.
            d. Actuated valves.
            e. Blowers.
        i. MBR Air Scour Blowers.
            a. Installed standby
            b. Isolation valve(s).
            c. Pressure relief valve(s).
            d. Pressure gauge(s).
            e. Check valve(s).
        ii. PA Blowers.
            a. Installed standby.
            b. Isolation valve(s).
            c. Pressure relief valve(s).
            d. Pressure gauge(s).

e. Check valve(s).
f. Fully Automated Membrane Clean System
for Recovery, Maintenance Clean, CIP or Backwash/backpulse.
    i. Backwash or Backpulse storage tank(s).
    ii. Chemical injection pump(s).
    iii. Isolation valves.
    iv. Check valves.
    v. Flow Meter(s).
    vi. Automated diversion valve(s).

g. Chemical Addition. Mandatory supply required, irrespective of design requirement..
    i. Carbon addition system.
        a. Pump(s).
        b. Valve(s).
        c. Flow measurement.
        d. Spill pallet.
    ii. pH adjustment system.
        a. Mix Tank(s).
        b. Mixer(s).
        c. Pump(s).
        d. Valve(s).
        e. Flow measurement
        f. Spill pallet.
    iii. Flux Enhancer, not allowed.

h. Operational Tools
    i. Provide the following operational tools:
        a. Filterability testing equipment.
        b. CSS testing equipment.
        c. Membrane Lifting tool.

i. Asset Management System
    i. Cloud based programming
    ii. Data Monitoring and Trending
    iii. Digital and searchable Operation and Maintenance Manual
    iv. Operational videos
    v. Remote connectivity

j. Spare Parts
    i. Membrane Unit (Large Membrane Sub-unit)
        a. Provide replacement components for one complete membrane module refurbishment. Components to include:
            1. A full set of membrane modules, cassettes or plates.
            2. O-rings.
            3. Tubes.
        b. The MBR System Supplier shall guarantee the shelf life of membrane spares. If shelf life is less than the first 48 months of the warranty period, the supplier shall provide a new set of spares on the expiration date of each shelf life period up until the completion of the first 48 months warranty period. For example if a shelf life is 1 year, the supplier provides a new set of spares at year 1, year 2 and year 3.
    ii. Membrane Air Scour Diffuser
        a. Complete diffuser assembly for one membrane unit.

2.5 GENERAL EQUIPMENT DESIGN, PERFORMANCE AND ASSEMBLY REQUIREMENTS

The MBR System includes all necessary subsystems to form a complete functional wastewater treatment plant. Subsystems shall be designed in accordance with the functional requirements described herein.

A. SUBSYSTEMS

1. General

a. System Operating Power Requirements

i. 480VAC/3PH/60Hz

b. Unless otherwise noted as off-board, subsystem components shall be factory installed, pre-plumbed and pre-wired.

c. Subsystem controls will be integrated into the PLC and SCADA within the MBR system Panel.

d. Motor control and HOA will be integrated into the MBR System Panel.

e. Electrical material and equipment shall have UL listing wherever standards have been established by that agency.

f. Complete electrical assembly shall meet all requirements of the National Electrical Code, the National Electrical Manufacturers Association (NEMA), the National Fire Protection Association (NFPA), and all applicable state and local codes.

g. All field instruments shall have identification tags meeting the following requirements:

i. Tag number of instruments shall match supplied P&IDs
ii. Tags shall be made of one of the following, depending on locations:
a. Stainless steel, engraved with 3/16-inch letters, and attached using a stainless steel cable.
b. Phenolic plastic with 3/16-inch letters, attached with double-faced tape.

2. Steel Tanks

a. See Section 2.04 Fabrication Requirements for design parameters.

3. Integration and Controls

a. MBR System Control Panel

i. The system shall include one single panel, factory installed on the equipment porch. The panel shall include components for the PLC, Motor Controls, HMI and HOAs.

ii. The panel shall be shipped factory installed and pre-wired to motors and components by the System Supplier.

iii. The panel shall be NEMA 4 rated.

iv. A UPS shall be included.

v. Climate control shall include:

a. Heater
b. Air conditioner in NEMA 4X housing.

b. PLC

i. The PLC shall be provided to control all equipment at the site. The PLC shall provide the functions described by the P&IDs and control narrative. The PLC program will be thoroughly documented to facilitate future troubleshooting or modifications.

ii. The System Supplier shall supply all equipment and custom software programming as required for a fully operational system, and shall provide the necessary hardware/software to allow for remote monitoring of the MBR System.

iii. The System Control Panel shall be factory installed on the Equipment Porch and pre-wired to other components on the Equipment Porch. Contractor to provide electrical power and conduit to the panel and between the panel and any electrical items shipped separate from the Equipment Porch.

iv. PLC Manufacture and Processor Model: Allen Bradley CompactLogix 5069-L306ER, No Substitute

c. SCADA System

i. Plant SCADA system shall include the following:
a. Graphical interface
b. Trending capability
c. Remote monitoring
d. Remote alarming
e. Remote plant control

ii. Remote monitoring and alarming shall include telephone contact to the plant Operator.

iii. A wireless station shall be factory installed in the panel so that a Digital OPS system may access digital functions within the area of the system.

iv. Plant SCADA system shall be run on a TFT VGA display panel mount operator interface located in the System Control Panel and factory installed.

4. Motor Controls

a. Motor Control Panel

i. The motor controls shall be provided to control equipment included with the

MBR System package. The MCP is integral with the MBR System Control Panel and shall provide Starters and VFDs as required for the system.

ii. Potentiometers for manual control of each variable frequency drive (VFD) shall be provided to allow for temporary manual operation.

iii. Hand-Off-Auto (HOA) switches for all major equipment shall be provided to allow for temporary manual operation.

5. Lot of Pipe and Electrical.

   a. Pipe, shall be factory installed.

      i. Liquid Service.

   a. PVC schedule 80 or 304 stainless

      ii. Air.

         a. 304 Stainless.

         b. Electrical, shall be factory installed.

   a. Water tight conduit.

6. Weirs.

   a. Weirs shall allow the following service:

      i. Hydraulically link zones.

      ii. Isolated zones.

      iii. Provide an over flow weir.

   b. A handle shall be provided for ease of removal.

   c. Manufacturer and Model: Halliday Series N1A or equivalent

7. Headworks

   a. See Section 2.02.A.5 for performance requirements.

   b. Manufacturer:
      a. EnviroCare. (Model Series: CT150. Basis of design)
      b. Approved equal.

8. PA Zone(s).

   a. The Pre-aeration process zone shall be employed for biological treatment.

b. PA zone shall be equipped with Fine Bubble Diffusers to introduce oxygen into the zone.

c. Diffusers shall be flat panel, non-clogging high strength polyurethane, with 316 SS body.

d. Clean water transfer efficiency 8.5-10%/m

f. Manufacturer:
   a. Aerostrip. (Model Series: T Series basis of design)
   b. Approved equal.

9. MBR Zones.

a. MBR process zones shall be used for biological treatment and to house the membrane units used to separate effluent from mixed liquor.

b. Membrane Design shall:

c. Have a maximum chlorine lifetime PPM hours of >5,000,000 ppm hours.

d. A MMF maximum Net Flux rate of 33 gfd at 10°C, sustainable for a maximum design frequency as show in Section 2.02.C Table 2-1.

e. Membrane Units (MU).

i. MUs shall be comprised of a diffuser case and membrane modules.

ii. MUs shall be constructed of type 316 stainless steel, PVC, or PE components as for operation submerged in mixed liquor as part of an MBR System.

iii. Acceptable membrane materials:
   a. Silicon Carbide (SiC), no substitute
   b. Polymeric

iv. Membrane shall be naturally hydrophilic. With not chemical additives.

v. Membrane modules shall have a dry storage duration of > 5 years.

vi. Modules shall incorporate Silicon Carbide rigid flat plates held firmly within the membrane module at a distance of 5.6 mm apart.

vii. Porosity shall be < 40%

viii. Maximum TMP 10%

ix. MUs shall be capable of being aerated during periods of no filtration.

x. MUs shall have integral diffuser and permeate manifolds.

xi. MUs shall be easy to recover from localized dewatering or clogging in the event of miss-operation or operation outside of normal operating conditions.

a. Only a routine Maintenance Cleaning shall be required following a dewatering event to recover specified performance.
b. In situ physical or mechanical cleaning only, no manual cleaning shall be required to recover.

xii. MUs shall be prefabricated, preassembled and factory certified before shipment to the site. Membrane units shall be installed at the factory. No installation of membranes units shall be done onsite.

xiii. Diffusers cases shall consist of a diffuser housing with individual non-clog air scour diffusers, each fed by a common manifold and easily replaceable.

xiv. Quality Control: Membranes are to be supplied by the membrane manufacturing company in which the MBR Supplier has an ownership share, no exceptions.

xv. Manufacturer:

a. Ovivo/Cembrane.
b. Approved Equalivalent

10. Pumps.

a. All on-board pumps irrespective of the service shall be of like type, make and model.
b. Each pump shall be rotary lobe.
c. Unless otherwise noted as off-board, subsystem components shall be factory installed, pre-plumbed and pre-wired.
d. Each pump shall have isolation valves and gauges on the inlet and outlet, to provide for ease of maintenance and removal.
e. Subsystem controls will be integrated into the PLC and SCADA within the MBR system Panel.
f. Motor controls and HOA will be integrated into the MBR System Panel.
g. Each pump shall have a remote disconnect.
h. Pump motor shall be inverter-duty rated and operated via Variable Frequency Drives.
i. Major pump components shall be cast iron for casings and NBR (Perbunan®).
k. Manufacturer:
    a. Vogelsang. (Model Series: VX100 basis of design)
    b. Approved equal.

12. Blowers.

a. Blowers provide air scour to the membranes and oxygen into the biological process.
b. Blower shall be Regenerative type.
c. Unless otherwise noted as off-board, subsystem components shall be factory installed, pre-plumbed and pre-wired.

d. Subsystem controls will be integrated into the PLC and SCADA within the MBR system Panel.

e. Blower motor shall be inverter-duty rated and operated via Variable Frequency Drives.

f. Motor controls and HOA will be integrated into the MBR System Panel.

g. Each blower shall have a remote disconnect.

h. Blower material shall be anodized aluminum.

i. Blowers shall accommodate a minimum surge or 1.5 psig under normal operating conditions.

j. Blowers shall be provided complete with inlet and exhaust silencers with filters, pressure relief valves, check valves, motors, pressure gauges, and mounting equipment. Fittings shall be stainless steel.

k. Sound level shall be ≤77 dba @ 5'.

m. Manufacturer:
   a. FPZ, (Model Series: SCL basis of design)
   b. Approved equal.

13. Membrane Clean System:

a. Provide a fully functional Membrane Cleaning System, for recovery, maintenance clean, CIP or backwash/backpulses as required.

b. System shall be fully automated and not require any operator intervention. Manual or Semi-Automatic systems are unacceptable.

c. System shall include:

   i. Mix tank(s).
   ii. Backwash or Backpulse storage tank(s).
   iii. Chemical injection pump(s).
   iv. Isolation valves.
   v. Check valves.
   vi. Flow Meter(s).
   vii. Automated diversion valve(s).

d. Manufacturer: MBR System Supplier Selection

14. WAS Subsystem:

a. Provide a fully functional Wasting System.

b. System shall be fully automated and not require any operator intervention.

c. Sludge shall be removed from membrane tanks.

d. Storage or solids handling will be by others.

e. System shall include:

   i. WAS Pump
   ii. TSS probe
   iii. Automated Diversion valves(s)
   iv. Isolation valves.
   v. Gauges
   vi. Check valves.

f. Manufacturer of WAS Pump:
   a. Vogelsang, (Pump Model Series: VX100 basis of design)
   b. Approved equal.

h. Manufacturer of Ancillary Equipment, MBR System Supplier selected.

15. Rescreen Subsystem:

a. Provide a fully functional Rescreen System.

b. Rescreen 15% of the total system tank volume on a daily basis.
c. Rescreen shall be taken from each membrane tank.
d. System shall be fully automated and not require any operator intervention.

e. System shall include:

   i. Rescreen Pump
   ii. Automated Diversion valves(s)
   iii. Isolation valves.
   iv. Gauges
   v. Check valves.

f. Manufacturer of WAS Pump:
   i. Vogelsang, (Pump Model Series: VX100 basis of design)
   ii. Approved equal.

h. Manufacturer of Ancillary Equipment, MBR System Supplier selected.

16. Analytics

a. Analytics will provide system measurements used for operational control and adjustments.

b. Unless otherwise noted as off-board, subsystem components shall be factory installed, pre-plumbed and pre-wired.

c. Subsystem controls will be integrated into the PLC and SCADA within the MBR system Panel.

d. Transmembrane Pressure Measurement (TMP)

i. Permeate Pressure transmitter shall be used for calculating the TMP of the membrane units.
ii. The TMP pressure transmitter shall produce a 4-20mA signal for PLC input.
iii. Manufacturer: Endress + Hauser, Approved equal.

e. Flow Meter(s).

i. The flow meter shall be used to measure the instantaneous flow of treated effluent.
ii. The flow meter shall produce a 4-20mA signal for PLC input.
iii. Manufacturer: Endress & Hauser, Approved equal.

f. Turbidity Meter(s).

i. The turbidity meter shall be provided for membrane integrity and effluent quality monitoring.

g. Manufacturer:

i. HACH,
ii. Approved equal.

h. Controller(s).

i. Multi-channel controller that operates multiple sensors.

i. Manufacturer:

i. HACH,
ii. Approved equal.

j. Dissolved Oxygen (DO).

i. DO measurement shall be sampled continuously. This provides for automatic operational adjustments for DO control in the process zones.

ii. One probe shall be supplied for each aeration zone.

iii. Manufacturer:
  i. HACH,
  ii. Approved equal.

i. Level Transmitter.

i. Ultrasonic.

ii. Manufacturer:
  i. Blue Ribbon
  ii. Approved equal.

j. Level Switch.

i. Mechanical.

ii. Manufacturer:

i. Conery
ii. Approved equal.

k. Total Suspended Solids (TSS)

i. TSS measurement shall be sampled continuously in the MBR zone. This provides for operational adjustments to control the MLSS level in the MBR zone.

ii. Manufacturer:
i. HACH,
ii. Approved equal.

17. Chemical Addition System(s)

a. Chemical addition may be required for the biological process capacity or efficiency of the MBR system.

b. Unless otherwise noted as off-board, subsystem components shall be factory installed, pre-plumbed and pre-wired.

c. The MBR Supplier shall provide spill pallet(s) for chemical drums.

d. Subsystem controls will be integrated into the PLC and SCADA within the MBR system Panel.

e. Carbon.

i. The supplemental carbon system shall be supplied to maintain a healthy biomass and meet effluent nutrient limits as defined in table 2-3.

ii. The carbon dosing system shall be sized such than sufficient carbon is provided to support the process requirements.

iii. The System Supplier shall provide detailed information on proposed operation strategy including scenarios and triggers calling for addition.

iv. Dosing Pump(s)

a. The pump shall dose carbon as required to the designated zone show on the project PIDs.

b. The dosing pump must be self-priming and variable speed adjustable.

c. Manufacturer and Model: MBR Supplier Selected.

f. pH Adjustment System.

i. The pH adjustment system shall be supplied to keep the influent pH within the required parameters in order to maintain a healthy biomass.

ii. The dosing system shall be sized such than sufficient magnesium hydroxide is provided to support the process requirements.

iii. The System Supplier shall provide detailed information on proposed operation strategy including scenarios and triggers calling for addition.

g. Drum Mixer.

i. A drum mixer shall be supplied to maintain a complete mix solution.

ii. The mixer shall be a clamp mount for easy change out of the chemical drum.

iii. Manufacturer and Model: MBR Supplier Selected.

18. Access Platforms.

a. Walkways and Platform shall be provided to gain safe operational access to zones and equipment.

b. Handrails shall be provided in areas that are elevated.

c. Stairs shall provide access to upper equipment porches.

d. Handrails shall be provided in areas that are elevated.

e. Manufacturer: MBR Supplier Selected.

19. Asset Management.

a. The supplier shall provide a cloud based mobile digital management tool for the first year of operation.

b. Management tool shall be software based. Interactive PFD’s or similar shall not be acceptable.

c. A hard-wired internet connection with a unique IP address shall be supplied by the Owner. Alternatively, the MBR System Supplier can provide cellular internet connectivity at an additional cost.

d. This application shall be accessible from any internet or cellular connected device and the data shall be stored on a cloud server. Owner authorizes installation of manufacturer-provided communication devices and manufacturer access to any data transferred in accordance with security compliance documentation.

e. The application must have all of the features and modules listed below and the accessibility of those modules shall be based on the licensing terms.

i. Status of the asset: Asset management tool shall be able to show the status of the assets at the plant (e.g. operational, idle, decommissioned, etc).

ii. Asset Import: Manufacturer assets shall be pre-loaded into the asset management tool.

iii. Asset Location: Ability to map the asset out via map or image-map.

iv. Asset Life Expectancy: Tracking of asset useful life.

v. Critical Asset Identification: Asset tool shall provide ability to identify which assets are most critical to normal operation.

vi. Asset Documentation: Asset manufacturer shall provide digital O&M documentation. All necessary instructional videos and documents shall be provided for equipment models specific to this facility. A minimum of 20 videos of two minutes or less and necessary procedures including data sheets, control narratives, troubleshooting guidelines, service manuals, drawings, and P&IDs shall be included in the media library for the assets. All pre-loaded videos and other content must be copyrighted or licensed by the Manufacturer. All asset documentation shall be accessed from the application and available in the cloud from any internet-connected device.

vii. Quote and Parts Ordering: Asset management tool shall include the ability to request quotes from manufacturers of the assets listed.

viii. Asset Knowledge Management: The asset management tool will allow the end-user to directly attach additional or revised material such as documents, videos, training and maintenance information in accordance with applicable storage limits. The end user should be able to attach any of these items to the specified asset from the mobile device camera or stored files.

ix. Support Contact Details: The user can add and update support contact details specific to each asset.

x. Maintenance Management: The application will provide maintenance management functionality such as work order requests via scheduled tasks and condition-based maintenance reminders.

xi. Maintenance Scheduling: Manufacturer will provide maintenance schedule for applicable assets within the application. End user will be able to create their own maintenance schedules or work orders with any of the assets in the application.

xii. Data Monitoring and Trending:

a. The application shall include reliable access to real-time data monitoring as outlined in the end-user license agreement from the Manufacturer-supplied control system, including all instrument readings and equipment statuses as referenced in this specification section.

b. The application shall have the ability to log data, build trendlines, and create HMI visualizations separate from the controls system. End-user shall be able to easily construct and save custom graphs and HMI widgets.

c. With a reliable internet connection, the data shall trend in near real-time with a minimum update every 30 seconds as outlined in the end user license agreement. Trending and HMI widgets shall be accessible and of a responsive design for a mobile device.

xiii. Alert Management

a. The application shall send customized text and / or email alerts specified by the end-user based on boolean logic functions of instrumentation or equipment status supplied in this section.

b. User shall have the ability to acknowledge alerts within the application.

c. Users shall be able to identify to whom they would like the alerts to be sent including individuals outside of the plant if they choose.

3.1 GENERAL FABRICATION REQUIREMENTS

The MBR System includes all necessary subsystems to form a complete functional wastewater treatment plant. Subsystems are designed in accordance with the functional requirements described herein.

A. STEEL TANK AND EQUIPMENT PORCHES

1. Design

a. Tanks shall be designed to support all hydrostatic, equipment, wind, live, and seismic loads as indicated on the drawings and in this specification.

b. The system design shall comply with the following structural criteria:

i. Maximum stresses on all tank components (walls, beams, tubing, etc.) shall not exceed 60% of yield.

ii. Maximum allowable deflection of any single member: 1/2”

c. Tank design shall include an anchoring system as necessary to meet wind and seismic resistance requirements as defined in state codes.

d. Tank design shall provide lifting lugs.

e. Maximum width shall be no more than 8.5 feet (excluding any removable sections).

f. Maximum height shall be no more than 12 feet (excluding any removable covers).

g. Tank system shall include integral equipment porches containing all pumps and blowers and associated piping, instrumentation, electrical cabinets/disconnects, and control panels. Porches shall have hand railings as required by code.

h. Tank system shall include access stairs or ladders to facilitate maintenance of the process and process equipment

2. Materials

   a. Plates, Angles, and Channel Shapes:

      i. Carbon steel plates, angles and shapes shall conform to the requirements of ASTM A-36 with a minimum yield strength of 36,000 psi.

      ii. Wall floor and wall plates shall be ¼” thickness.

      iii. Aluminum plates, angles and shapes shall be 6061 alloy with a T6 temper.

   b. Carbon Steel Pipe: Carbon steel pipe shall conform to the requirements of ASTM A-53, type S, Grade B and ASME B16.10, schedule 40.

   c. Stainless Steel Pipe: Stainless steel pipe shall conform to the requirements of ASTM A-312, TP304 and ASME B36.19, schedule 10 or 40, as specified in tank drawing nozzle schedule.

   d. Unistrut: Unistrut structural members shall be P1000, 1 5/8”, stainless steel.

3. Fabrication.

   a. Tank welding shall conform to the requirement of ANSI/AWWA D-100-05: Welded Carbon Steel Tanks for Water Storage.

   b. Tank welding shall conform to the requirement of ANSI/AWWA D-100-05: Welded Stainless Steel Tanks for Water Storage.

   c. All welds shall be continuous seal welds.

   d. Tank construction shall conform to applicable sections of AISC, 13th Edition of the Steel Construction Manual.

4. Piping.

   a. All MBR System air scour piping shall be Type 304 stainless steel.

   b. Permeate piping shall be schedule 80 PVC.

   c. Piping shall have welded, glued, flanged, or mechanical groove (Victaulic) connections.

   d. Pipe supports shall be 304 stainless steel Unistrut (or equivalent) systems or 304 stainless steel angle and structural shapes with stainless hardware, clamps, and guides.

   e. Transitions from MBR Supplier piping to Contractor’s piping shall use ANSI 150 pound flat face flanges unless otherwise noted or coordinated with the Contractor.

5. Finishes, Carbon Steel Tanks

a. All internal and external carbon steel surfaces shall be painted.

b. All stainless steel surfaces and piping shall be painted.

c. Internal

   i. Preparation: Prepare internal tank surfaces to a near white metal blast of 3 mil profile per SSPC-SP10, free of all visible oil, grease, dirt, dust, mill scale, rust, paint, oxides, corrosion products, and other foreign matter.

   ii. Application: Apply interior paint in one coat to a 10-14 mils DFT thickness. Deposit by stripe coat on inside and outside corners followed by an immediate full coat application. Material should be brushed into cavities behind pipe penetration flanges as part of the stripe coat process. Observe all coating manufacture's requirements for application (pot life and recoat times).

   iii. Paint shall be Carboline Phenoline Tank Shield, no substitute

d. External.

   i. Preparation: Prepare internal tank surfaces and equipment porches to a near white metal blast of 3 mil profile per SSPC-SP10, free of all visible oil, grease, dirt, dust, mill scale, rust, paint, oxides, corrosion products, and other foreign matter.

   ii. Application: Apply exterior epoxy primer paint at 3-6 mils DFT in one coat. The underside of the tank shall be treated as the exposed sides. Apply top-coat of polyurethane paint @ 2-3 mils thickness. Observe all coating manufacture's requirements for application (pot life and recoat times).

   iii. Epoxy Primer Paint shall be Carboline Carboguard 893. Top-coat shall be polyurethane Carboline Carbothane 134, no substitute.

e. Finish Color.

   i. Standard

      a. Carboline Gull Grey 2713 shall be used on all corrugated surfaces.

      b. Carboline Light Grey C705 on all non-corrugated surfaces.

f. Inspection and Testing.

   i. 100% visual inspection shall be performed to insure that there are no runs, sags, blisters, voids or any other irregularities.

   ii. Dry Film Thickness (DFT) testing shall be performed in accordance with SSPC PA 2, with the exception of the number of test "Spots". One (1) spot, consisting of three (3) readings shall be taken per every Five (5) square feet of surface.

iii. Holiday detection shall be performed in accordance with NACE RP 0188-99. A low voltage DC current at 67 ½ volts wet sponge shall be used.

PART 3 - PROJECT DELIVERY

3.2 PROJECT EXECUTION

A. Unless otherwise required in the Contract Documents, the MBR Supplier shall provide all submittal documentation as described in this Section no later than 2 weeks after receipt of purchase order and notice to proceed.

B. Unless otherwise required in the Contract Documents, the MBR Supplier shall ship all components in their Scope of Supply, as described in this Section, no later than 12 weeks after receipt of written submittal approval.

3.3 COMPLETE SYSTEM FACTORY ACCEPTANCE TEST

A. Prior to shipment, the MBR System Supplier shall coordinate and conduct a system factory acceptance test (FAT) of the MBR Complete MBR System which will include:

1. The PLC control logic and HMI operability shall be demonstrated by systematically forcing I/O to verify all controls functions and HMI screen representations defined in the system control narrative

2. The MBR control panel shall be inspected for completeness, integrity and workmanship.

3. The MBR Package system shall be completely connected including ancillary equipment, all interconnecting piping, interconnecting electrical and interconnecting communications. Wet test of the system with a complete hydraulic run through demonstrating the functionality of all pumping and blower subsystems shall be performed.

4. The MBR System Supplier shall furnish all materials, instruments, and incidental and expendable equipment required for Acceptance Testing of the Goods, except where otherwise specified.

5. The MBR supplier shall arrange and pay for travel and lodging for two of the Owner's representatives to witness the Acceptance Testing. Travel may be extended to attend pre-training sessions, see specification 3.02.B.

6. The MBR System Supplier shall keep detailed notes regarding the FAT and record all test data and results. Upon successful completion of the Acceptance Testing, the Supplier shall submit a written report on the FAT.

B. Prior to shipment, the MBR System Supplier shall coordinate a two (2) day pre-training session of the MBR System after completion of the FAT which will include:

1. A combination of classroom and hands-on training. All training shall be conducted at the supplier's location.

2. The required materials, texts, and supplies.

3. Equipment Operation:

    a. Describe equipment operating (process) function.

    b. Describe equipment's fundamental operating principles.

    c. Identify equipment's mechanical, electrical, and electronic components and features.

    d. Identify all support equipment associated with the operation of subject equipment.

    e. Recommend standard operating procedures to address start-up, routine monitoring, and shut-down of the equipment.

4. Detailed Component Description:

    a. Identify and describe in detail each component's function.

    b. Group related components into subsystems, where applicable. Describe subsystem functions and their interaction with other subsystems

    c. Identify and describe in detail equipment safeties and control interlocks

5. Equipment Preventive Maintenance (PM):

    a. Describe PM inspection procedures required to:

        i Perform an inspection of the equipment in operation.

        ii Spot potential trouble symptoms and anticipate breakdowns.

        iii Forecast maintenance requirements (predictive maintenance).

    b. Define the recommended PM intervals for each component.

    c. Provide lubricant and replacement part recommendations and limitations.

    d. Describe appropriate cleaning practices and recommend intervals.

    e. Identify and describe the use of special tools required for maintenance of the equipment.

    f. Describe component removal/installation and disassembly/assembly procedures.

    g. Perform "hands-on" demonstrations of preventive maintenance procedures.

h. Describe recommended measuring instruments and procedures, and provide instruction on interpreting alignment measurements, as appropriate.

i. Define recommended torque, mounting, calibration, and/or alignment procedures and settings, as appropriate.

j. Describe recommended procedures to check/test equipment following a corrective repair.

6. Equipment trouble shooting;

a. Define recommended systematic troubleshooting procedures.

b. Provide component specific troubleshooting checklists.

c. Describe applicable equipment testing and diagnostic procedures to facilitate troubleshooting.

7. Control System. Training is to include:

a. Navigation of all HMI screens and menus.

b. Review of automatic operations and controls.

c. Changing process set points.

d. Overriding controls from the HMI.

e. Manual operation of the system in the event of a power failure.

f. Trouble shooting.

3.4 MATERIALS INSPECTION

A. The Contractor shall inspect delivered equipment upon arrival on site for completeness of scope delivery and to verify that all components have arrived undamaged. The Contractor is responsible for notifying the Supplier of deficiencies in quantities or conditions within 28 days from the ship date.

B. The Contractor shall provide all labor, materials, and equipment for unloading, de-crating, organizing, and compiling take-off of received MBR equipment, components, and instrumentation.

C. The Supplier shall make available, upon the request of the Contractor, personnel to assist in the inspection of the Supplier's equipment upon unload at the site. Supplier's personnel shall provide services in accordance with their standard daily rates.

3.5 SYSTEM COMMISSIONING

A. The MBR System Supplier shall coordinate with the Contractor, Engineer, and Owner for execution of the System Commissioning. In advance of System Commissioning the MBR System Supplier shall perform an onsite Mechanical Inspection of the facility and generate a punchlist of inconsistencies. The Contractor is required to resolve the punchlist items to the satisfaction of the System Supplier, prior to scheduling System Commissioning.

B. The MBR System Supplier shall prepare a "Detailed Plan of Commissioning Activities" that will be used as a guideline for Commissioning of the Goods provided by the Supplier. The Detailed Plan of Commissioning Activities shall be used to coordinate the activities of the Supplier's and Owner's personnel. The "Detailed Plan of Commissioning Activities" will identify the Commissioning requirements for all Goods supplied by the MBR System Supplier. The guidelines shall include the following:

1. General inspection of systems (lubrication, rotation, calibration).
2. Loop checking, instrumentation, and control system verification.
3. Pipe loss testing.
4. Clean water permeability testing.
5. Sludge seeding.
6. Biological process system.
7. Chemical feed systems and Clean-in-Place.
8. Commissioning of equipment.
9. Start-up activities.
    a. Feed, Filtered Water and Backwash Flow Pressure and Level Control Sequences.
    b. Membrane Treatment Unit Operations including filtration, relaxation, backwashing, and clean in place.
    c. Normal and Emergency Start Up and Shut Down Sequences.
    d. Process Interlocks
10. Training

C. Failure to complete the Commissioning as required by this Section within the allocated time shall constitute a failure of the MBR System Supplier to provide Special Services in accordance with the requirements of the Contract.

D. The Contractor shall provide materials and personnel in support of the System Commissioning to fill tanks with clean water, transfer fluids, repair/remedy any and all electrical and mechanical issues, provide temporary tie-ins, temporary piping, transfer pumps, etc.

E. The Contractor shall coordinate with the Engineer and Owner to seed the MBR system with sludge at the conclusion of the clean water testing. The MBR Supplier is not responsible for supplying the seed sludge.

F. The System Commissioning shall begin at the Contractor's discretion, within the limits defined herein:

   1. Successful completion of a pre-commissioning Mechanical Inspection is required.

   2. Start of Commissioning shall be no later than 30 days after completion of Mechanical Inspection.

G. The Owner shall operate the plant during the Commissioning Period; however, Supplier and Contractor shall be allowed to provide onsite assistance.

H. Supplier is responsible for monitoring operating conditions and performance during the Commissioning Period.

I. The MBR Supplier shall place the Goods into operation and perform tests to determine if equipment is operating properly. The purpose of these tests is to verify that both the System and each Unit are:

   1. Properly installed.

   2. Operational.

   3. Capable of completing an operating cycle free of problems.

   4. Free from pump or valve cavitation, water hammer, overheating, overloading, vibration, or other operating problems

   5. The MBR System Supplier shall verify that control programming has been configured with appropriate software time delays to avoid rapid pump or membrane flow cycling in response to transient dynamic hydraulic effects caused by backwash, or chemical washing cycles or other process cycles (e.g. start -up, shut down, membrane test). "Dead-heading" or any operation of any pump under a "zero-flow" or "flow condition below the pump manufacturers acceptable limits" is not acceptable. Interlocks shall be provided to prevent operation of the any pump under a "dead- headed" condition. The pump manufacturers recommended "maximum number of pumps starts per hour" shall not be exceeded.

J. As a part of commissioning, the MBR System Supplier shall start-up and operate all support systems provided by or required by the Supplier for operation of the system, including but not limited to chemical feed systems, instrumentation, air compression equipment, and electric controls. This testing shall demonstrate that there are no water or air leaks in the system, that the piping has been installed and connected properly, that the electrical system is operating correctly, and that the instrumentation has been properly calibrated.

K. The MBR System Supplier shall furnish materials (excluding chemicals and power), instruments, and incidental and expendable equipment required for commissioning/placing the Goods into operation. The Supplier shall retain the services of any manufacturer's representatives as required in the Contract Documents to assist with commissioning/placing into operation of the Goods. The costs of these services shall be borne by the MBR System Supplier.

L. Membrane permeate quality shall be evaluated to determine compliance of the MBR System with Performance Requirements. If the MBR system fails to comply with requirements of membrane permeate quality, Supplier shall provide the Owner and the Engineer a written plan of recommended modifications to the system (such as repairing damaged fibers, replacing seals, complete replacement of system) to achieve compliance with the requirements. Upon implementation of modifications plan, the permeate quality tests shall re-commence in their entirety.

M. When requested by the MBR System Supplier, the Engineer shall review the operation of the equipment to verify that the commissioning is complete.

1. The Engineer shall perform random tests on equipment and witness various operational sequences to confirm general conformance to the Contract Documents

2. The Engineer shall initiate alarm conditions and perform random tests on the control system to confirm general conformance to the Contract Documents.

3. The Engineers review shall include a review of the HMI interface and PLC SCADA system commissioning requirements to determine conformance with the Equipment specifications and requirements of the Project. The Engineers review shall identify any equipment that has not been properly installed, or operating, detailing the outstanding installation issues on a "punch list" and noting the party who shall be responsible for each correction and identify the items require that correction.

4. Upon satisfactory completion of the review, the Engineer shall submit to the MFEM a written "Notice of Completed Commissioning"

N. Once the "Notice of Completed Commissioning" is issued, Training of Operation and Maintenance Personnel may commence.

3.6 TRAINING

A. The MBR System Supplier shall provide Training in the maintenance and operation of all systems included in the Supplier’s control system.

B. Failure to complete the Training as required by this Section within the allocated time shall constitute a failure of the MBR System Supplier to provide Special Services in accordance with the requirements of the Contract.

C. The Supplier shall provide formal training of the Owner's personnel. Training shall commence after the "Notice of Completed Commissioning" is issued.

D. Training of the Owner's personnel shall commence within a period of five (5) days after the "Notice of Completed Commissioning" has been issued as mutually agreed to by the Owner, Engineer, Contractor and Supplier. All training shall be performed by the MBR System

Supplier or a factory-certified representative of the supplier or component supplier. Training is to include:

1. Navigation of all HMI screens and menus.
2. Review of automatic operations and controls.
3. Changing process set points.
4. Overriding controls from the HMI.
5. Manual operation of the system in the event of a power failure.
6. Component equipment.
7. Instrument components.
8. Routine Maintenance.
9. Maintenance cleaning.
10. Biological process theory.
11. Biological processes.
12. Membrane filtration theory.
13. Daily, weekly and monthly checklists and reports.
14. Forecast maintenance requirements (predictive maintenance)
15. Trouble shooting.

E. The MBR System Supplier shall provide a combination of classroom and hands-on training. All training shall be conducted at the Owner's location.

1. The MBR System Supplier shall be responsible for all costs associated with training and shall provide required materials, texts, and supplies.
2. Training sessions shall be video recorded by the MBR System Supplier at the Supplier's expense.

F. The MBR System Supplier shall develop and submit to the Engineer and Owner a Training Manual. The Training Manual shall include the elements presented in this Section or as required by the MBR System Supplier or component equipment supplier.

1. The Supplier shall prepare a Training Lesson Plan, provide qualified instructors, and schedule the training in an organized manner.
2. Credentials for the MBR System Supplier's designated instructor(s) shall be submitted thirty (30) days prior to the commencement of training. Credentials shall include a brief resume and specific details of the instructor(s) pertaining both to personal experience

operating and maintaining the specified equipment and conducting operation and maintenance for the same equipment.

3. The Supplier’s proposed lesson plans shall detail specific instruction topics. Training aids to be utilized in the instruction shall be referenced and attached where applicable to the proposed lesson plan. "Hands-on" demonstrations planned for the instruction shall be described in the lesson plan.

4. The Supplier shall indicate the estimated duration of each segment of the training in the lesson plan.

5. Submit information as required by the local primacy agency in support of Professional Development Hours.

3.7 DEMONSTRATION

A. The MBR System Supplier shall provide demonstration testing of the membrane bioreactor equipment.

B. Failure to complete the Demonstration as required by this Section within the allocated time shall constitute a failure of the MBR System Supplier to provide Special Services in accordance with the requirements of the Contract.

C. The demonstration shall commence after the "Notice of Completed Training" is issued.

D. Demonstration shall extend for a period of 30 days.

E. The Engineer shall document the time when the facilities are substantially unavailable for use by the MBR System Supplier to perform Demonstration Testing due to circumstances beyond the control of the Suppliers including but not limited to power outages, lack of feedwater, inability to transfer product water or feedwater due to factors beyond the control of the MBR System Supplier, not having adequate staff from the Contractor or the Owner. If in the sole opinion of the Engineer the facilities are substantially unavailable to the Supplier, equivalent additional Demonstration Testing time will be granted without penalty.

F. Upon completion of the Performance Testing, the MBR Supplier shall submit to the Owner a written report detailing the results of the Demonstration Testing. The report shall include, at a minimum, the following sections:

   1. Introduction

   2. Overview of demonstration testing procedures.

   3. Summary of testing results.

   4. Appendices that include a copy of all field notes and test data.

G. The purpose of the Demonstration Testing is to demonstrate that MFEM furnished equipment is:

1. Properly installed.

2. Ready to be placed into service by the Owner.

3. In compliance with the service conditions, performance requirements, material specifications, and all other requirements of the Contract Documents.

H. The MBR System Supplier shall furnish all materials, instruments, and incidental and expendable equipment required for Acceptance Testing of the Goods, except where otherwise specified.

I. During the Demonstration period, the MBR SYSTEM SUPPLIER is solely responsible for identifying water quality parameters, instrumentation and control programming required to satisfy and maintain effluent requirements. The MBR SYSTEM SUPPLIER shall establish instrumentation alarm and shutdown limits to prevent operation of the equipment outside the established limits.

1. The Owner shall maintain a high speed connection to the processor but all data monitoring shall be the responsibility of the MBR SYSTEM SUPPLIER. The Owner shall not be required to monitor, report or record instrument field data for process warranty purposes.

2. The Owner shall monitor Influent and effluent BOD, TSS, TN, TP, Total Coliform and Turbidity and procure lab results as required by the MBR Suppliers guidelines.

J. A representative of the MBR System Supplier shall be present on site during the first five (5) days of the Demonstration period. Throughout the Demonstration period, a representative of the MFEM shall be available via means of cellular communication including non-working hours in case of an emergency.

K. The Owner or an authorized representative of the Owner will be present to witness the Performance Testing.

L. The Owner or an authorized representative of the Owner shall operate the plant as directed by the MBR System Supplier.

M. The MBR System Supplier shall keep detailed notes regarding the Performance Testing and record all test data and results. This will be done through operation of the data logging system.

N. If the System does not perform in accordance with the Contract Documents, the Supplier shall return or remain on site to perform all necessary corrections at the cost of the MBR System Supplier until compliance with Contract Documents is demonstrated.

O. During the Demonstration period, the System shall perform in accordance with the guaranteed product water quality to allow the Owner to discharge treated water.

P. Any interruption of the Performance Testing caused by circumstances beyond the control of the MBR System Supplier shall not require the testing to be restarted from the beginning. Such events include any activities that would result in an inadvertent or unplanned shutdown of the PLC / HMI control System or otherwise interfere with the Performance Test. The elapsed time of Performance Testing prior to the interruption will be applied to the required testing period.

END OF SECTION

SECTION 461000 – AIR JET CHOPPER PUMPS

PART 1 - GENERAL

1.1 DESCRIPTION OF THE WORK

A. The CONTRACTOR shall furnish and install air jet chopper pumps as specified herein and according to the plans and drawings.

B. All parts shall be designed and proportioned for ample strength, stability, and stiffness for their intended purposes.

C. Pump(s) shall be designed for submerged continuous-duty and be specifically intended to pump and agitate waste solids at heavy consistencies and to aerate the pumped liquid. Motors shall be rated for the classified area in which they will be located.

D. Pump manufacturer shall be ISO 9001 certified.

E. Motor(s) shall be the heavy-duty asynchronous speed type, as specified in this section.

PART 2 - PRODUCTS

2.1 Operation Conditions and Requirements

1. Type of tank: Precast Septic Tank
2. Number of tanks: 1
3. Tank dimensions, [ft.]: 7'-8" × 16'-7" × 7'-11"
4. Liquid volume, [gallons]: 5,000
5. Type of liquid: Waste-Activated Sludge
6. Dry matter solids content, [%]: 0.8
7. Liquid temperature, [°F]: Ambient
8. Required Oxygen Transfer per tank, SOTR, [lbs/day]: N/A
9. Number of AirJet units per tank: One
10. Total number of AirJet units: One
11. Motor size, [HP]: As Required
12. Power supply, [phases/voltage/hertz]: 3ph/480V/60Hz
13. Classification: Class 1, Division 1

2.2 ACCEPTABLE MANUFACTURERS

A. Subject to compliance with the requirements of this specification, air jet chopper pumps manufactured by the following are acceptable:

1. Landia, Inc. Model DG-I (Basis of Design)

2. Engineer approved equal.

2.3 PUMP DESIGN

A. Pump Casing

1. Casing shall be of gray cast iron AISI A48-40B with all water passages to be smooth, and free of blowholes and imperfections that inhibit good flow characteristics. Fabricated casings will not be accepted.
2. Front and back suction plates shall be machined such that all solids are directed away from the seal area. In addition, back pump out vanes on the impeller shall eliminate debris from collecting around the seal area.
3. An anti-clog bar shall be mounted on the pump volute in conjunction with the stationary knives. The impeller shall incorporate a raised vane tip, which, in conjunction with the anti-clog bar, will eliminate stringy material from clogging at the impeller eye. Pump designs that require a cleanout plug in the pump casing shall not be accepted.

B. Pump Assembly

1. All mating surfaces where watertight sealing is required shall be machined and fitted with Nitrile rubber O-rings. Fitting shall be such that sealing is accomplished by metal-to-metal contact between machined surfaces, resulting in compression of the O-rings without requiring specific torque limit. No secondary sealing compounds, rectangular gaskets, elliptical O-rings, grease, or other devices shall be used.

C. Chopping System

1. Chopping/maceration of solids shall be accomplished by the action of two rotating knives moving across one fixed knife (alternatively three fixed knives) mounted by the pump inlet external of the pump casing. The chopping system shall be designed to prevent the pump inlet from clogging
2. Rotating and fixed knives shall be easily replaceable without the use of special tools or requirement of pump disassembly.
3. Fixed and rotating knives shall be of steel AISI A570 Gr.36 and heat-treated to 60 Rockwell C Hardness.

D. Impeller

1. Impeller shall be open type cast iron AISI A48-40B and dynamically balanced. The impeller shall be rigidly held in place with an impeller bolt and shall require no axial adjustments and no setscrews. Fabricated impellers shall not be acceptable.
2. The impeller shall not be required to assist in any chopping/macerating function. Pump designs that require the impeller to chop solids shall not be accepted.

E. Motor

1. The pump motor shall be submersible of the asynchronous speed type, housed in an air-filled, watertight chamber. The stator winding shall be insulated with moisture resistant Class F insulation, which shall resist temperatures of 315°F. The stator shall be dipped and baked three times in Class F varnish. The motor shall be designed for continuous-duty, capable of sustaining a maximum of 10 evenly spaced starts per hour. The rotor bars and short circuit rings shall be made of aluminum. The motor shaft, delivered with the rotor as an integral part, shall be shaft steel AISI 4340. The stator housing shall be of gray cast iron AISI A48-40B.

2. The thermal sensors, embedded in the stator winding and wired into the pump control, shall monitor over temperature. These shall supplement the external motor over current protection located in the control panel.

F. Cable Entry

1. The cable entry shall be an integral part of the stator casing. The cable entry shall be composed of a conical cable holder with a flange bearing against a shoulder in the stator-casing opening. The cable entry cone shall be of gray cast iron AISI A48-40B. Sealing shall be accomplished by metal-to-metal contact between machined surfaces resulting in compression of the O-ring. The cable shall be cast into the cable entry cone providing a leak-proof, torque-free seal at the cable entrance. No terminal board in the motor is required.

G. Air Ejector System

1. Aeration shall be accomplished by means of air induction through ejectors permanently mounted on the tank floor. The pump discharge shall connect to the ejectors via a vertical slide motion when lowering the pump on its guide pipe. The liquid shall accomplish the mixing of the air and liquid as it is pumped through the nozzle chamber increasing the liquid velocity. This creates a consistent negative pressure in the ejector system resulting in air being drawn down through the air suction pipe. The turbulent mixture of air and liquid as it passes through the ejector nozzle is then flushed out through the ejector by means of high pressure.
2. One complete air ejector system shall be furnished per pump. The air ejector system shall be constructed of AISI 304 stainless steel. The pump manufacturer to ensure compliance shall manufacture the complete air ejector system.

H. Seals

1. Each pump shall be provided with a double mechanical seal system, each containing one stationary silicon carbide ring and one rotating silicon carbide part running in the oil for cooling and lubrication. They shall be mounted on the motor shaft to isolate the oil chamber from the dry motor stator housing and the medium from the oil chamber. The impeller and pump casing back plate design, both having pump out vanes to reduce seal area pressure and to prevent any build-up of solids between impeller and pump casing, shall protect the outer mechanical seal.
2. Each pump shall be provided with an oil chamber for the shaft sealing system. Drains and inspection plugs shall be provided with positive anti-leak seal and shall be accessible from the outside.
3. Mechanical seals shall not require a lubrication monitoring system to ensure reliability.

I. Shaft and bearings

1. The pump motor shaft shall rotate on two permanently lubricated bearings. The inner and outer bearing shall be single row, deep-groove ball bearings calculated for an L-10 life of 100,000 hours at full load.
2. The motor shaft shall be Alloy Steel AISI 4340.
3. The impeller shall be directly attached to the motor shaft. No shaft coupling shall be required.

2.4 ACCESSORIES:

A. Guide Rail Assembly

1. A guide rail assembly shall be used to support each pump during operation and to guide the units during installation and regular preventative maintenance inspection. The system shall consist of a bottom-bearing console, a stop bracket, a single square tube guide pipe, a fixing bracket and a guide holder assembly. All major components shall be constructed of AISI 304 stainless steel.
2. The bottom assembly shall be bolted to the floor of the tank and provide support for the guide rail and designed so the pump discharge will connect to the air ejectors when the pump is properly seated.
3. The upper guide holder assembly shall secure the system to the tank wall, platform, or under manhole/hatch/cover, as required by the application. It shall also provide the lateral support for the guide rail. The assembly shall contain a location to secure the electrical motor cable holder.

B. Crane Arm Assembly

1. One portable crane arm assembly shall be provided to easily and safely raise and lower the mixer for installation and inspection.
2. The crane assembly shall consist of a crane arm with telescopic capabilities, rotatable at 360º, a hand winch with brake for load control with stainless steel wire, a three-pronged hook and an intermediate piece.
3. The assembly shall be positioned directly into the guide pipe and shall not require any additional crane socket to be installed on the gangway/platform.
4. The three-pronged hook shall work in conjunction with the mixer's suspension bracket. The lifting system shall not require any lifting cables or chains, apart from the power cable, to be permanently attached to the mixer. Lifting systems that require permanently submerged chains or lifting cables will not be accepted.
5. The crane arm assembly shall be fabricated of stainless steel or hot dip galvanized steel.
6. The mixer manufacturer to ensure compliance shall manufacture the crane. No third party cranes will be accepted.

C. Fasteners

1. All fasteners shall be of AISI 316 stainless steel.
2. Manufacturer shall supply anchor bolt design calculations, signed and stamped by an engineer licensed in the State of Hawaii.

2.5 QUALITY ASSURANCE:

A. Factory Test: The Pump Manufacturer shall perform the following inspections and tests on each pump before shipment from the factory:

1. A balancing of the motor (rotor).
2. A dry run pump test to verify correct rotation and mechanical integrity. The entire unit is checked for vibration.
3. A Full Load Motor Test (run dry for 5 minutes at full load) to verify electrical data measurements. All electrical data shall be registered as part of documentation.
4. A submerged test of the pump where pump casing is exposed to an over pressure of 15 PSI.
5. A motor and cable insulation test for moisture content and insulation defects.
6. A final inspection of impeller, motor rating, and electrical connections for compliance with purchase order.
7. All inspections and tests shall be executed under ISO 9001 certification.

8. The pump performance shall be substantiated by a model test of each pump model and size. For pumps exceeding 60 HP each unit shall be tested in a pump test stand.

B. Manufacturer’s Services:

1. Following completion of the installation the Pump Manufacturer shall provide a qualified representative to verify proper installation and assist in equipment startup and maintenance training for the Owner’s personnel.

END OF SECTION 463000