

**WATER BOOSTER PUMP SKID REPLACEMENT**

**BID NO. 8808-J7**

**TECHNICAL**  
**SPECIFICATIONS**  
**and**  
**DRAWINGS**

**SECTION 00 01 11**

**SEALS PAGE**

The engineering material and data contained in these Specifications were prepared under the supervision and direction of the undersigned, whose seal as registered professional engineer is affixed below.

Date of Issue: August 28, 2026



Jenna McDonald, P.E.  
Woodard & Curran (Engineer)

**END OF SECTION**

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## **SECTION 01 11 00**

### **SUMMARY OF WORK**

#### **PART 1 – GENERAL**

##### **1.01 SECTION INCLUDES**

- A. Project Description
- B. Description of the Work
- C. Work Sequence and Coordination

##### **1.02 PROJECT DESCRIPTION**

- A. The Project is generally described as the replacement of the potable water booster pump skid at the City of Worcester's Water Filtration Plant located at 71 Stone House Hill Road in Holden, MA, and all materials, equipment, services, and construction inherent to the Work .

##### **1.03 DESCRIPTION OF THE WORK**

- A. The Work includes labor, material and equipment, services required for construction, testing, and commissioning of the Project in accordance with the Contract Documents and as more specifically described in the Specifications and Drawings and includes, but is not limited to, the following principal features.
  - 1. Remove and dispose of the existing potable water booster pump skid.
  - 2. Clean, repair, and paint the existing concrete equipment pad.
  - 3. Furnish and install a new prefabricated tri-plex potable water booster skid with all necessary internal piping, pumps, motors, valves, electrical, instrumentation, and controls and other necessary appurtenances.
  - 4. Complete final start up, testing, and training and all material and equipment, construction and services inherent to the Work.
- B. Work Site locations: The City of Worcester's Water Filtration Plant located at 71 Stone House Hill Road in Holden, MA 01520 and generally as shown on the Drawings.
- C. Existing conditions and Site data: per the Drawings.

##### **1.04 WORK SEQUENCE AND COORDINATION**

- A. Sequence

1. Sequence Work to minimize shutdowns and reflect sequencing in the construction schedule.
- B. Coordination
  1. Ensure that facilities and water system flows are maintained and remain in service at all times unless otherwise approved.
    - a. Obtain written approval of the Engineer for shutdowns. Notify Engineer a minimum of two weeks prior to any required shutdowns.
    - b. Prepare a Shutdown Plan for each requested shutdown indicating what existing valves must be operated by Owner personnel during the shutdown.
      - 1) Perform Work requiring shutdowns at the Water Filtration Plant only between the hours of 8:00PM and 4:00AM.
    - c. Coordinate Work with the City and provide public notice, as required.
  2. Maintain access to facilities for the Owner throughout the Project.

**PART 2 PRODUCTS - NOT USED**

**PART 3 EXECUTION - NOT USED**

**END OF SECTION**

## SECTION 01 11 05

### OVERALL GENERAL REQUIREMENTS (CONSTRUCTION)

#### PART 1 – GENERAL

##### 1.01 SUMMARY

- A. This Section specifies the overall general requirements for execution of the Work, supplements some items in the Contract and applies to all Specifications and Drawings, including:
  - 1. Administrative and procedural requirements (relating to the process of contract administration, and the methods of communicating, controlling, and assuring quality);
  - 2. Temporary facilities and controls (put into place for use only during the period of construction and that will be removed when no longer required for construction operations);
  - 3. General execution requirements; and
  - 4. Startup/commissioning and performance testing.

- B. Section Includes

- 1.02 PRICE AND PAYMENT PROCEDURES

- Schedule of Values
    - Payment Procedures
    - Change Procedures
    - Measurement and Payment Procedures
    - Correlation of Submittals

- 1.03 ADMINISTRATIVE REQUIREMENTS

- Project Management and Coordination; Meetings
    - Documentation of Progress
    - Submittal Procedures
    - Closeout Procedures

- 1.04 QUALITY REQUIREMENTS

- Reference Standards and Regulatory Requirements
    - Qualifications

#### PART 2 - PRODUCTS

- 2.01 SOURCE QUALITY CONTROL

- General
    - Independent Testing Agency Certification

Factory Testing

- 2.02 PRODUCT REQUIREMENTS
  - General
  - Transportation and Handling
  - Storage and Protection

PART 3 - EXECUTION

- 3.01 TEMPORARY CONSTRUCTION FACILITIES
  - Barriers
  - Protection of Work
  - Security
  - Safety Facilities
  - Access Roads
  - Parking
  - Field Offices
  - Progress Cleaning and Waste Removal
- 3.02 TEMPORARY UTILITIES
- 3.03 TEMPORARY CONTROLS
  - Pest Control
  - Dust Control
  - Noise Control
  - Pollution Control
- 3.04 REMOVAL OF TEMPORARY UTILITIES, FACILITIES,  
AND CONTROLS

- 3.05 OVERALL EXECUTION REQUIREMENTS
  - Coordination
  - Existing Conditions
  - Field Engineering
  - Record Documents
  - Cutting and Patching
  - Electrolytic Corrosion Prevention
  - Quality Assurance and Control of Installation
  - Manufacturers' Field Services
  - Independent Testing
- 3.06 STARTUP, TESTING, AND COMMISSIONING
  - Spare Parts
  - Consumables
  - Checkout and Starting Systems
  - Starting, Adjusting, and Balancing
  - Startup and Commissioning/Performance Testing
  - Demonstration and Training

## 1.02 PRICE AND PAYMENT PROCEDURES

### A. Schedule of Values

- 1. Submit preliminary and final Schedule of Values.
  - Number of hardcopies: **0**
  - Submit electronically via Engineer's web-based electronic document management control system in PDF format.
- 2. Provide sufficient detail to allow for determination of the value of the Work at any degree of completion.
- 3. For each line item, identify number and title of related specification section.

### B. Payment Procedures

- 1. Submit Application for Payment using the form provided by Engineer or Owner. Utilize latest approved Schedule of Values for listing items in Application for Payment. Provide supporting documentation for items included in the Application for Payment.
  - a. Number of hardcopies: **0**
  - b. Submit electronically via Engineer's web-based electronic document management control system in PDF format.
- 2. Payment Period: at intervals stipulated in the Agreement.

3. Submit an updated Progress Schedule with each Application for Payment.
- C. Change Procedures
1. Utilize forms included in the Contract Documents.  
  
Number of hardcopies: 0  
  
Submit electronically via Engineer's web-based electronic document management control system in PDF format.
  2. Field Order: issued by Engineer or Owner to advise of minor changes in the Work not involving an adjustment to Contract Price or Contract Time.
  3. Change Request: issued by Engineer, Owner or Contractor to request or authorize minor variations and deviations, amendments or supplements to the Contract Documents. Initiate requests for substitute items using a Change Request.
    - a. Engineer or Owner to include a detailed description of a proposed change with supplementary or revised Drawings and Specifications, including a change in Contract Times related to the change (with a stipulation for any overtime work required) and the period of time during which the requested price will be considered valid. Prepare and submit an estimate within 15 days.
    - b. Contractor to describe the proposed change and its full effect on the Work. Describe the reason for the change and the effect on the Contract Price and Contract Time with full documentation (and a statement describing the effect on Work by separate or other contractors). Document any requested substitutions.
  4. Work Change Directive: issued by Engineer or Owner, signed by Engineer or Owner and instructing Contractor to proceed with a change in the Work. Work authorized in a Work Change Directive will be included in a subsequent Change Order. Document will describe changes in the Work, and designate method of determining any change in Contract Price or Contract Time. Promptly execute the change.
  5. Change Order: issued by Engineer or Owner.
    - a. *Stipulated Price Change Order*: based on Contractor's maximum price quotation or Contractor's request for a Change Order as approved by Engineer or Owner.
    - b. *Unit Price Change Order*: for pre-determined unit prices and quantities and executed on a fixed unit price basis. Execute Work under a Work Change Directive for unit costs or quantities of work not pre-determined. Changes in Contract Price and Contract Time to be computed as specified for Time and Material Change Order.

- c. *Time and Material Change Order*: based on itemized account and supporting data after completion of change. Engineer or Owner and Contractor to determine the change allowable in Contract Price and Contract Time. Maintain detailed records of work done on this basis, provide full information required for evaluation of proposed changes, and substantiate costs for changes in the Work.
  - 6. Substitutes and "Or Equals": Request substitute items as a Change Request in accordance with subparagraph C.1.b. above, with complete data substantiating compliance of proposed substitution with Contract Documents.
    - a. Substitute items will be processed in accordance with subparagraph 1.03.C.6 below.
    - b. Substitute items will not be considered when indicated or implied on Shop Drawing or material and equipment data submittals without separate written request, or when acceptance will require revision to the Contract Documents.
- D. Measurement and Payment Procedures
  - 1. Unit Prices
    - a. Take measurements in presence of Engineer and compute quantities. Engineer or Owner to verify and also take measurements and quantities. Notify Engineer or Owner in advance when measurements must be taken.
    - b. Unit quantities and measurements indicated in the Bid Form, if any, are for Contract purposes only. Actual quantities and measurements supplied or placed in the Work determine amount of payment.
  - 2. Payment includes full compensation for required labor, material and equipment, tools, plant, transportation, services and incidentals; erection, application or installation and construction of an item of the Work; and overhead and profit, unless otherwise indicated.
- E. Correlation of Submittals
  - 1. Promptly revise Schedule of Values and Applications for Payment to record each authorized Change Order as a separate line item and adjust the Contract Price.
  - 2. Promptly revise Progress Schedule to reflect any change in Contract Times and revise sub-schedules to adjust time for other items of the Work affected by the change.
  - 3. Promptly enter changes in Project Record Documents.

### 1.03 ADMINISTRATIVE REQUIREMENTS

#### A. Project Management and Coordination; Meetings

1. Contact information for Owner and other entities related to the Project and special coordination requirements and contacts during prosecution of the Work will be provided at the pre-construction conference.
2. Inform Owner and Engineer of the address for sending official correspondence and the address and telephone number of Contractor's representative who will be project manager and Site superintendent for the Contract and identify the 24 hour, 7 days per week emergency response telephone or cell phone number that is staffed by a person (not a passive answering machine) or provide that a phone call will be returned within one hour.
3. During periods of construction and testing keep Owner and Engineer informed in writing with name, address, and telephone number of Contractor's representative who will be responsible and available outside of normal working hours for emergency repairs and the maintenance of safety devices.
4. Identify correspondence, submittals, drawings, data and materials, packing slips or other items associated with this Contract as follows:

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5. Coordinate scheduling, submittals, and Work of the various Specifications to effectuate an efficient and orderly sequence for installing interdependent construction elements, with provisions for accommodating items installed later.
6. Preconstruction Conference and Site Mobilization Meeting
  - a. Owner to schedule an initial preconstruction conference.
  - b. Attendance required by Owner, Contractor, Engineer, Contractor's Superintendent, Project Manager, Subcontractors and major Suppliers as needed.
  - c. Agenda
    - Distribute Contract Documents
    - Discuss design concepts
    - Discuss preliminary Progress Schedule, Schedule of Submittals, Schedule of Values and preliminary cash flow projections.
    - Designate personnel representing each party; communication procedures

- Procedures and processing of submittals, substitutions, applications for payments, Change Orders and Contract closeout procedures
  - Scheduling
  - Use of premises by Owner and Contractor
  - Owner's requirements and partial occupancy
  - Construction facilities and controls provided by Owner
  - Temporary utilities provided by Owner and Contractor
  - Survey and Site Layout
  - Security and housekeeping procedures
  - Schedules
  - Procedures for testing
  - Procedures for maintaining record documents
  - Requirements for start-up
  - Inspection and acceptance of equipment put into service during construction period
  - Access, laydown and coordination with others
- d. Engineer will record minutes and distribute draft copies prior to the next scheduled meeting to Owner and Contractor for review, then revise as required and distribute within 2 weeks thereafter to meeting participants, with copies to Owner and Contractor, and those affected by decisions made.

7. Progress Meetings

- a. Owner to schedule progress meetings beginning no later than 60 days after the Initial Conference and continue thereafter with an agreed upon frequency throughout progress of the Work.
- b. Attendance required by Contractor, Contractor's Superintendent, major Subcontractors and Suppliers, Owner and Engineer as appropriate to agenda topics for each meeting.
- c. Agenda:
- Review minutes of previous meetings
  - Unresolved Issues
  - Review Work progress
  - Observations, problems, and decisions
  - Identification of problems which impede planned progress
  - Review of Schedule of Submittals and status of submittals
  - Review of off-Site fabrication and delivery schedules
  - Maintenance of progress schedule
  - Corrective measures to regain projected schedules
  - Planned progress during succeeding Work period
  - Coordination of projected progress
  - Maintenance of quality and Work standards

- Effect of proposed changes on Progress Schedule and coordination
  - Other business relating to Work
- d. Engineer will record minutes and distribute draft copies prior to the next scheduled meeting to Owner and Contractor for review, then revise as required and distribute within 2 weeks thereafter to meeting participants, with copies to Owner and Contractor, and those affected by decisions made.
8. Pre-installation Conference and Coordination Meetings
- a. When required, convene a pre-installation conference at Site before commencing certain Work that requires coordination or has special requirements or approvals or convene coordination meetings as may be generally required.
  - b. Attendance required by parties directly affecting, or affected by, Work of the specific Specification section. Notify Owner and Engineer 5 days in advance of pre-installation conference. Party requesting general coordination meeting to notify other party.
  - c. Review conditions, preparation and procedures, and coordination with related Work.

B. Documentation of Progress

1. Submit preliminary and final Progress Schedules.
- Number of hardcopies: 0
- Submit electronically via Engineer's web-based electronic document management control system in PDF format.
- a. Show complete sequence of construction by activity, identifying Work of separate stages and other logically grouped activities. Indicate the early and late start, early and late finish, float dates, and duration.
  - b. Indicate estimated percentage of completion for each item of Work at each submission.
  - c. Indicate dates for fabrication, factory testing, delivery, shipping and field testing, and material and equipment delivery dates, including those furnished by Owner. Coordinate with Schedule of Submittals.
2. Submit revised Progress Schedule on monthly basis and with each Application for Payment, identifying changes since previous version. Coordinate content with Schedule of Values, if any.
3. Submit weekly Safety Reports signed by the responsible on-Site person.

4. Documentation of Pre-Construction Conditions, Construction Progress, and Final Conditions
  - a. Documentation of Pre-Construction Conditions
    - 1) Submit photographs prior to starting construction to record Site conditions. Ensure existing conditions that might be affected by the Work are clearly recorded. Identify photographs with date, time, orientation and Project identification. Re-take any photograph furnished which, in the opinion of the Engineer, is of poor quality or incomplete at no additional cost to Owner.
      - a) Format: PDF or JPG format, minimum 300 dpi quality and a minimum resolution of 6.0 megapixels. Identify photographs with date, time, orientation and Project identification.
        - Number of hardcopies: 0
        - Submit electronically via Engineer's web-based electronic document management control system in PDF format.
    - 2) Digital video record, in color, the Project Site. Ensure existing conditions that might be affected by the Work are clearly recorded. Include clear and concise audio descriptions of the existing Project Site conditions with date, time, orientation and Project identification. Re-record any recordings furnished which, in the opinion of the Engineer, are poor quality or incomplete at no additional cost to Owner.
      - a) Format: digital videodisc (DVD) format.
        - Number of hardcopies: 0
        - Submit electronically via Engineer's web-based electronic document management control system.
  - b. Documentation of Construction Progress: not required.
  - c. Documentation of Final Conditions
    - 1) Submit photographs with Application for Final Payment to record final conditions. Identify photographs with date, time,

orientation and Project identification. Re-take any photograph furnished which, in the opinion of the Engineer, is of poor quality or incomplete at no additional cost to Owner.

- 2) Format: PDF or JPG format, minimum 300 dpi quality and a minimum resolution of 6.0 megapixels. Identify photographs with date, time, orientation and Project identification.
  - a) Number of hardcopies: 0
  - b) Submit electronically via Engineer's web-based electronic document management control system in PDF format.

C. Submittal Procedures

1. Schedule submittals to expedite the Project and coordinate with schedules required by Paragraph 1.03.B above. Deliver each submittal in the quantity indicated to Engineer and to Owner where required as follows. Coordinate submission of related items.

Engineer:

Woodard & Curran  
138 River Road, Suite 212  
Andover, MA 01810  
Attn: Jenna McDonald  
Phone: 781-613-0326  
Email: [jmcdonald@woodardcurran.com](mailto:jmcdonald@woodardcurran.com)

Owner:

City of Worcester  
71 Stonehouse Hill Road, Holden, MA 01520  
Attn: Sean M. Divoll  
Phone: 508-799-1493  
Email: [divolls@worcesterma.gov](mailto:divolls@worcesterma.gov)

2. Present submittals in a clear and thorough manner, in English and using English units. Use sheet size of not less than 8 1/2 by 11 inches and not more than 24 by 36 inches. Provide space for Contractor, Engineer, and Owner's review stamps.
3. Revise and resubmit documents as required. Identify all changes made since previous submittal. Distribute copies of reviewed submittals to concerned parties. Instruct parties to promptly report any inability to comply with provisions. Submittals not requested on the submittal schedule may not be recognized or processed.
4. Schedule of Submittals: Submit preliminary and final Schedule of Submittals. Include all submittals specified in Agreement and other Specification sections.

Number of hardcopies: 0

Submit electronically via Engineer's web-based electronic document management control system in PDF format.

- a. Include description of each submittal, date by which each submittal will be delivered to Engineer and Owner date by which each submittal must be approved to maintain project schedule, and relevant section reference.

- b. Allow 15-30 days from receipt of submittal/resubmittal for Engineer review of submittals and possible resubmittal.
5. Shop Drawings and Samples: Submit in accordance with the Schedule of Submittals required in subparagraph 1.03.C.4 above.

Number of hardcopies: 0

Submit electronically via Engineer's web-based electronic document management control system in PDF format.

- a. Complete the submittal transmittal form included as an attachment to this Section as is indicated, numbering each submittal consecutively. Assign resubmittals the same transmittal number as the original with a suffix of a sequential letter to indicate the resubmittal (e.g. the first resubmittal of submittal 25 would be number 25A.) Include only those documents previously issued under original transmittal number in resubmittals. Do not combine new submittals with resubmittals.
- b. Attach a transmittal form to each group of Shop Drawings, manufacturer's literature, equipment data and Samples submitted. Use a sufficient number of transmittal forms so that: items on a single transmittal form pertain to the same equipment item, specification section or element of Work; items on a single transmittal form are either original submittals or the same number resubmittal; and each Sample is listed on a separate transmittal form. Data shown on the Shop Drawings shall be complete with respect to quantities, dimensions, specified performance and design criteria, materials, and similar data to show Engineer the services, materials, and equipment Contractor proposes to provide.
- c. Submittals which do not have a fully completed transmittal form will be returned along with unreviewed attachments. Returned submittals, even though incomplete, will be counted as a submittal.

- d. Before submitting each Shop Drawing or Sample, Contractor shall have:
  - 1) reviewed and coordinated each Shop Drawing or Sample with other Shop Drawings and Samples and with the requirements of the Work and the Contract Documents;
  - 2) determined and verified all field measurements, quantities, dimensions, specified performance and design criteria, installation requirements, materials, catalog numbers, and similar information with respect thereto;
  - 3) determined and verified the suitability of all materials offered with respect to the indicated application, fabrication, shipping, handling, storage, assembly, and installation pertaining to the performance of the Work; and
  - 4) determined and verified all information relative to Contractor's responsibilities for means, methods, techniques, sequences, and procedures of construction, and safety precautions and programs incident thereto.
- e. Each submittal shall bear a stamp or specific written certification that Contractor has satisfied Contractor's obligations under the Contract Documents with respect to Contractor's review and approval of that submittal.
- f. Engineer's Review
  - 1) Engineer will provide timely review of Shop Drawings and Samples in accordance with the Schedule of Submittals acceptable to Engineer. Engineer's review and approval will be only to determine if the items covered by the submittals will, after installation or incorporation in the Work, conform to the information given in the Contract Documents and be compatible with the design concept of the completed Project as a functioning whole as indicated by the Contract Documents.
  - 2) Engineer's review and approval will not extend to means, methods, techniques, sequences, or procedures of construction (except where a particular means, method, technique, sequence, or procedure of construction is specifically and expressly called for by the Contract Documents) or to safety precautions or programs incident thereto. The review and approval of a separate item as such will not indicate approval of the assembly in which the item functions.

- 3) Engineer's review and approval shall not relieve Contractor from responsibility for any variation from the requirements of the Contract Documents unless Contractor has complied with the requirements of subparagraph C.6. below. Engineer's review and approval shall not relieve Contractor from errors or omissions in a Shop Drawing or Sample.
- g. Resubmittal Procedures
  - 1) Contractor shall make corrections required by Engineer and shall return the required number of corrected copies of Shop Drawings and submit, as required, new Samples for review and approval. Contractor shall direct specific attention in writing to revisions other than the corrections called for by Engineer on previous submittals.
  - 2) Contractor shall furnish required submittals with sufficient information and accuracy in order to obtain required approval of an item with no more than 3 submittals. Engineer will record Engineer's time for reviewing subsequent submittals of Shop Drawings, samples, or other items requiring approval and Contractor shall reimburse Owner for Engineer's charges for such time.
  - 3) In the event that Contractor requests a change of a previously approved item, Contractor shall reimburse Owner for Engineer's charges for its review time unless the need for such change is beyond the control of Contractor.
6. Variations: Clearly identify requests for "Or-Equal" and substitute items and submit per subparagraph 1.02.C.1.b above. Substitute items will not be considered when indicated or implied on Shop Drawing or material and equipment data submittals without separate written request, or when acceptance will require revision to the Contract Documents. Identify variations from Contract Documents and material and equipment or system limitations which may be detrimental to successful performance of the completed Work and identify reasons therefor at no additional cost to Owner.. Engineer will be allowed a reasonable time within which to evaluate each proposal or submittal made and may require Contractor to furnish additional data about the proposed substitute item. Engineer will be the sole judge of acceptability. No "or equal" or substitute will be ordered, installed or utilized until Engineer's review is complete, which will be evidenced by a Change Order in the case of a substitute and an approved Shop Drawing for an "or equal."

- a. “Or Equal” Items: If in Engineer’s sole discretion an item of material or equipment proposed by Contractor is functionally equal to that named and sufficiently similar so that no change in related Work will be required, it may be considered by Engineer as an “or equal” item, in which case review and approval of the proposed item may, in Engineer’s sole discretion, be accomplished without compliance with some or all of the requirements for approval of proposed substitute items. A proposed item of material or equipment will be considered functionally equal to an item so named:
  - 1) if in the exercise of reasonable judgment Engineer determines that it is at least equal in materials of construction, quality, durability, appearance, strength, and design characteristics; it will reliably perform at least equally well the function and achieve the results imposed by the design concept of the completed Project as a functioning whole; and it has a proven record of performance and availability of responsive service; and
  - 2) Contractor certifies that, if approved and incorporated into the Work there will be no increase in cost to the Owner or increase in Contract Times and it will conform substantially to the detailed requirements of the item named in the Contract Documents.
- b. Substitute Items: If in Engineer’s sole discretion an item of material or equipment proposed by Contractor does not qualify as an “or-equal” item subparagraph 6.a above, it will be considered a proposed substitute item. Contractor shall submit sufficient information as provided below to allow Engineer to determine if the item of material or equipment proposed is essentially equivalent to that named and an acceptable substitute therefor. Requests for review of proposed substitute items of material or equipment will not be accepted by Engineer from anyone other than Contractor.
  - 1) Contractor shall certify that the proposed substitute item will perform adequately the functions and achieve the results called for by the general design, be similar in substance to that specified, and be suited to the same use as that specified.
  - 2) Contractor shall state the extent, if any, to which the use of the proposed substitute item will prejudice Contractor’s achievement of Substantial Completion on time, whether use of the proposed substitute item in the Work will require a change in any of the Contract Documents (or in the provisions of any other direct contract with Owner for other work on the Project) to adapt the design to the proposed substitute item, and whether incorporation or use of the

proposed substitute item in connection with the Work is subject to payment of any license fee or royalty.

- 3) Contractor shall identify all variations of the proposed substitute item from that specified; available engineering, sales, maintenance, repair, and replacement services; and shall provide an itemized estimate of all costs or credits that will result directly or indirectly from use of such substitute item, including costs of redesign and claims of other contractors affected by any resulting change.
- 4) Engineer will advise Contractor in writing of any negative determination. Engineer will record Engineer's costs in evaluating a substitute proposed or submitted by Contractor. Whether or not Engineer approves a substitute so proposed or submitted by Contractor, Contractor shall reimburse Owner for the reasonable charges of Engineer for evaluating each such proposed substitute. Contractor shall also reimburse Owner for the reasonable charges of Engineer for making changes in the Contract Documents (or in the provisions of any other direct contract with Owner) resulting from the acceptance of each proposed substitute.

7. Manufacturers' Installation Instructions and Certificates: Submit printed instructions for delivery, storage, assembly, installation, start-up, adjusting, and finishing. Indicate special procedures, perimeter conditions requiring special attention and special environmental criteria required for application or installation.

Number of hardcopies: 0

Submit electronically via Engineer's web-based electronic document management control system in PDF format.

- a. Submit manufacturers' certificates for recent or previous test results on material or equipment, but they must be acceptable to Engineer and Owner. Indicate material or equipment conforms to or exceeds specified requirements and provide supporting reference date, affidavits, and certifications as appropriate.
- b. Submit test results, data, and reports and certifications to Engineer based on tests performed. Submit test reports and certifications for independent testing services specified.

8. Record Documents and Closeout Submittals: Submit record documents described in Paragraph 3.05.D. below and per Paragraph 1.03.D below.
  - a. Legibly mark each item to record description of actual equipment and material installed and actual construction on the Drawings and approved submittals, including the following.
    - 1) Manufacturer's name and equipment and material model and number
    - 2) Material and equipment substitutions or alternates utilized
    - 3) Approved changes
    - 4) Measured depths of foundations
    - 5) Measured horizontal and vertical locations of Underground Facilities and appurtenances, referenced to permanent surface improvements
    - 6) Measured locations of internal utilities and appurtenances concealed in construction, referenced to visible and accessible features of the Work
    - 7) Field changes of dimension and detail
    - 8) Details not on original Contract Documents or Shop Drawings
  - b. *As-Builts for Material and Equipment*:  
Number of prints: **3**  
Electronic format: DWG  
Submit electronically via Engineer's web-based electronic document management control system.  
Indicate "As-Supplied" in revision block and sign. Show all changes and revisions to Final Completion per Paragraph 3.05.D.
  - c. *Drawings Conformed by Contractor to Construction Records*:  
Submit the following.  
Number of prints: **3**  
Electronic format: PDF  
Submit electronically via Engineer's web-based electronic document management control system.

Indicate "Conformed by Contractor to Construction Records" in revision block and sign. Show all changes and revisions to Final Completion per Paragraph 3.05.D.

- d. *Warranties and Guarantees:* Submit duplicate notarized copies of warranty documents which are executed and transferable from Subcontractors, Suppliers, and manufacturers. For items of Work delayed beyond date of Substantial Completion, provide updated submittal within 10 days after acceptance, listing date of acceptance as start of Warranty Period.
- 1) Submit in searchable PDF format via Engineer's web-based electronic document management control system in PDF format.
  - 2) Submit **2** copies in ring binders with durable plastic covers and table of contents.

e. Operation and Maintenance Data (if applicable)

- 1) Submit draft of completed volumes 30 days prior to final inspection. Include 2 copies of completed manuals with major equipment when equipment is shipped. Draft copies will be reviewed and returned after final inspection, with Engineer's comments. Revise content of all sets as required.

Number of hardcopies: **2**

Submit in searchable PDF format via Engineer's web-based electronic document management control system.

- 2) For final volumes within 10 days after final inspection. Submit in searchable PDF format via Engineer's web-based electronic document management control system.

Submit 2 copies of data in ring binders with durable plastic covers with 8 1/2 by 11 inch text pages. Cover: title "OPERATION AND MAINTENANCE INSTRUCTIONS", title of Project, and subject matter of binder when multiple binders are required.

- 3) Subdivide binder contents with permanent page dividers, logically organized as described below with laminated plastic tabs and clearly print the contents. Prepare a Table of Contents for each volume, with material, equipment, or system description identified, in three parts as follows:

**Part 1:** Directory, listing names, addresses, and telephone numbers of Contractor, Subcontractors, and major equipment Suppliers, and service representative.

**Part 2:** Operation and maintenance instructions arranged by system and subdivided by Specification section.

For each system, identify names, addresses, and telephone numbers of Subcontractors and Suppliers. Identify the following:

- Significant design criteria
- List of equipment with As-Builts certified “As-Supplied”
- Parts list for each component
- Operating instructions
- Inspection, maintenance and adjustment instructions for equipment and systems
- Lubrication and maintenance schedules
- Maintenance instructions for special finishes, including recommended cleaning methods and materials, and special precautions identifying detrimental agents
- Troubleshooting guides
- Schematic diagrams

**Part 3:** Material Safety Data Sheets

**Part 4:** Other Project documents and certificates, including the following:

- Certificates
- Photocopies of warranties

**D. Closeout Procedures**

1. Substantial Completion shall have been achieved when Work is complete, systems are successfully operating, and final testing has been successfully completed and Contractor considers the entire Work ready for its intended use; a full inventory of the spare parts and special tools purchased by the Owner are replenished and in the custody of the Owner; the Site has been restored to the satisfaction of the Owner; an inspection of the Work has been completed by the Engineer and the Owner; and an updated Punch List is provided. The Contractor shall have sole care, custody, and control of the Work until achievement of Substantial Completion.
2. Notify Owner and Engineer in writing that the entire Work is substantially complete (except for items specifically listed by Contractor as incomplete) using the Notice of Substantial Completion form included in the Contract Documents and request that Engineer issue a certificate of Substantial

Completion. Promptly after Contractor's notification, Owner, Contractor, and Engineer shall make an inspection of the Work to determine the status of completion. If Engineer does not consider the Work substantially complete, Engineer will notify Contractor in writing giving the reasons therefor.

3. If Engineer considers the Work substantially complete, Engineer will deliver to Owner a tentative certificate of Substantial Completion which shall fix the date of Substantial Completion using the Certificate of Substantial Completion included in the Contract Documents with Punch List attached. Owner shall have 7 days after receipt of the tentative certificate during which to make written objection to Engineer as to any provisions of the certificate or attached list. If, after considering such objections, Engineer concludes that the Work is not substantially complete, Engineer will, within 14 days after submission of the tentative certificate to Owner, notify Contractor in writing, stating the reasons therefor. If, after consideration of Owner's objections, Engineer considers the Work substantially complete, Engineer will, within said 14 days, execute and deliver to Owner and Contractor a definitive certificate of Substantial Completion (with a revised Punch List) reflecting such changes from the tentative certificate as Engineer believes justified after consideration of any objections from Owner.
4. The date of achieving Substantial Completion is the date set forth in the Certificate of Substantial Completion that is accepted and signed by the Owner.
5. During the period between Substantial Completion and the date for Final Completion, Contractor shall be given access to correct items on the Punch List and achieve Final Completion.
6. Upon written notice from Contractor that the entire Work or an agreed portion thereof is complete, Engineer will promptly make a final inspection with Owner and Contractor and will notify Contractor in writing of all particulars in which this inspection reveals that the Work is incomplete or defective. Contractor shall immediately take such measures as are necessary to complete such Work or remedy such deficiencies.
7. Final Completion shall have been achieved when Contractor has, in the opinion of Engineer, satisfactorily completed all corrections identified during the final inspection and has delivered, in accordance with the Contract Documents, documents including maintenance and operating instructions, schedules, guarantees, warranties, bonds, certificates or other evidence of insurance, certificates of inspection, marked up record documents, and other required documents, and Engineer has indicated that the Work is complete in accordance with the Contract Documents including the following.

- a. Final cleaning has been conducted and Contractor equipment and supplies including waste materials have been removed from the Site and legally disposed of.
  - b. Inspections required by Laws and Regulations are complete. Certificates and permits to occupy and operate have been issued if required.
  - c. Spare parts, maintenance and extra materials have been delivered in quantities specified to Project Site and stored as directed.
  - d. A Final Application for Payment has been submitted to the Engineer identifying total adjusted Contract Price, previous payments, and balance due along with required documentation including:
    - 1) all documentation called for in the Contract Documents
    - 2) consent of the surety, if any, to final payment
    - 3) a list of all Claims against Owner that Contractor believes are unsettled
    - 4) complete and legally effective releases or waivers (satisfactory to Owner) of all Lien rights arising out of or Liens filed in connection with the Work.
8. If the final application for payment is acceptable, Engineer will give written notice to Owner and Contractor that the Work is acceptable using the Notice of Completion form included in the Contract Documents. Owner will thereafter make final payment and acceptance per the Contract.

## 1.04 QUALITY REQUIREMENTS

### A. Reference Standards and Regulatory Requirements

1. Reference to standards, specifications, manuals or codes of any technical society, organization or association, or Laws or Regulations of any governmental authority are used whether such reference be specific or by implication, shall mean the standard, specification, manual, code, or Laws or Regulations in effect at the time of opening of Bids, except as may be otherwise specifically stated in the Contract Documents.
2. No provision of any such standard, specification, manual, or code, or any instruction of a Supplier, shall be effective to change the duties or responsibilities of Owner, Contractor, or Engineer, or any of their subcontractors, consultants, agents, or employees, from those set forth in the Contract Documents. No such provision or instruction shall be effective to assign to Owner, Engineer, or any of their officers, directors, members, partners, employees, agents, consultants, or subcontractors, any duty or authority to supervise or direct the performance of the Work or any duty or

authority to undertake responsibility inconsistent with the provisions of the Contract Documents.

3. Acronyms and abbreviations used are defined in the applicable versions of the Encyclopedia of Associations published by Gale (part of Cengage Learning) generally available in large libraries and on the internet.

B. Qualifications

1. Meet or provide capability to meet the criteria specified in connection with the Work of the Contract Documents.
2. As a minimum, Contractor shall:
  - a. have been regularly and actively engaged in similar Work as described in the Contract Documents, operating under the same business name and business organization structure, for the last 5 years on at least 5 projects;
  - b. have successfully completed at least 3 projects involving construction of similar facilities covered by the Contract Documents;
  - c. have a full-time on-Site superintendent in responsible charge of the Work with at least 10 years' experience as superintendent on comparable projects;
  - d. have a project manager assigned full-time with at least 10 years' experience as project manager on comparable projects; and
  - e. carry at least the insurance coverage and amounts required in the Contract.

## PART 2 – PRODUCTS

### 2.01 SOURCE QUALITY CONTROL

A. General

1. Subject material and equipment furnished under these Contract Documents to a complete factory testing program as specified.
2. Shop Drawings and submittals: reviewed by Engineer before initiating testing program.
3. Perform checks and tests in accordance with manufacturer's recommendations and referenced standards.
4. Evaluate test results and advise Owner immediately of any discrepancy between test results and test limits or the failure of any device or system

under test. Include test limits for acceptability applicable to each test on the certified test records.

5. Record test information, including the evaluation of testing results, on forms approved by Owner and Engineer.

B. Independent Testing Agency Certification

1. If specified, furnish certificates from an independent testing agency.
2. Independent testing agency to certify that material and equipment components have been examined and tested and are in conformance with the requirements specified in the Contract Documents.
3. Take Samples in accordance with the requirements specified in the Contract Documents, as selected by Owner or independent testing agency. Furnish and ship at no additional cost to Owner.

C. Factory Testing

1. Provide 14 days prior written notice of factory inspections and tests to Owner and Engineer.
2. If failure to give proper written notice results in material and equipment being assembled or covered before a factory inspection or test, make material and equipment ready for inspection or test and reassemble or recover at no additional cost to Owner.
3. Owner may inspect any portion of material and equipment furnished at any reasonable time during manufacture and may witness testing of any portion of material and equipment wherever located. Owner and Engineer to witness tests only.
4. Furnish, set up and operate test equipment and facilities.
5. If facilities for conducting required tests are unavailable to the manufacturer, conduct tests elsewhere or have them performed by an independent agency approved by Owner.
6. Protect material and equipment after testing and checking to provide that subsequent testing of other equipment or systems does not disturb, damage or otherwise interfere with functional capability of material and equipment.
7. Assume responsibility for protection of material and equipment and safety of all personnel during factory testing program.
8. Grounds for rejection: failure to withstand tests; failure to meet ratings; failure to meet applicable standards.

9. In the event of failure
  - a. Submit revisions of documents requiring approval for changes required for rectification.
  - b. Obtain Owner's and Engineer's approval before making such changes.
  - c. Provide written details of any changes to be made not requiring approval.
  - d. Notify Owner and Engineer in writing before retesting.
  - e. Furnish new material and equipment which meets requirements of the Specifications if rejected material and equipment cannot be rectified to satisfaction of Owner and Engineer.
  - f. Retest after rectification in presence of Owner or Engineer.
10. Assume responsibility for all costs, including, but not limited to: loss or damage to materials and equipment resulting from testing; retesting; rectification; new material and equipment to replace damaged or non-rectifiable material and equipment; removal, furnishing, transportation, unloading, and installation of replacement material and equipment; and witness of testing by Owner and Engineer including travel, lodging, meals, and payroll.
11. Submit certified test reports which define tests, list results, and are signed by Contractor's representative, and copies of raw data collected during tests in accordance with Paragraph 1.03.C above. Submission of certified test reports does not relieve Contractor of responsibility for material and equipment meeting requirements of the Contract Documents after installation.

## **2.02 PRODUCT REQUIREMENTS**

### **A. General**

1. Products include new material and equipment incorporated into the Work and may also include existing material and equipment required for reuse. This does not include machinery and equipment used for preparation, fabrication, conveying, installation and erection of the Work.
2. Do not use materials and equipment removed from existing Work Site, except as specifically permitted.
3. Provide complete with accessories, trim, finished, safety guards, and other devices and details need for a complete installation and for the intended use or effect.

4. Provide standard products which have been produced and used successfully on other similar projects for similar applications. Provide products which are likely to be available to Owner in the future for items required for maintenance and repair or replacement Work.
5. Furnish interchangeable components of the same manufacturer, for similar components.
6. Provide products that earn the Energy Star® and meet the Energy Star® specifications for energy efficiency.

B. Transportation and Handling

1. Transport and handle material and equipment in accordance with manufacturer's instructions.
2. Notify Engineer and Owner in writing upon acceptance of a shipment.
3. Promptly inspect shipments to assure that material and equipment comply with requirements, quantities are correct, and material and equipment are undamaged.
4. Furnish equipment and personnel to handle material and equipment by methods to prevent soiling, disfigurement, or damage.
5. Uncrate equipment and dispose of packing material properly.

C. Storage and Protection

1. Store and protect material and equipment in accordance with manufacturer's instructions, with seals and labels intact and legible. Store sensitive material and equipment in weather tight, climate controlled enclosures.
2. For exterior storage of fabricated material and equipment, place on sloped supports, above ground.
3. Provide for bonded off-Site storage and protection when Site does not permit on-Site storage or protection.
4. Cover material and equipment subject to deterioration with impervious sheet covering. Furnish ventilation to avoid condensation or potential degradation of material and equipment.
5. Store loose granular materials on solid flat surfaces in a well-drained area. Avoid mixing with foreign matter.
6. Furnish equipment and personnel to store material and equipment by methods to prevent soiling, disfigurement, or damage.

7. Arrange storage of material and equipment to permit access for inspection. Periodically inspect to assure material and equipment are undamaged and are maintained in acceptable conditions.
8. After receipt of material and equipment, assume responsibility for loss and damage including but not limited to breakage, corrosion, weather damage, and distortion.

## **PART 3 – EXECUTION**

### **3.01 TEMPORARY CONSTRUCTION FACILITIES**

#### **A. Barriers**

1. Furnish barriers to prevent unauthorized entry to and clear delineation of construction areas, to allow for Owner's use of Site, and to protect existing facilities and adjacent properties from damage from construction operations as recommended by OSHA and as otherwise required for the protection of life and property during construction.
2. Construct barricades and protective facilities in accordance with local and state regulations. Furnish and install signs, lights, reflectors, and such protection facilities as may be required.
3. Furnish barricades required by governing authorities for public rights of way.
4. Provide protection for plant life designated to remain. Replace damaged plant life.
5. Protect non owned vehicular traffic, stored materials, Site and structures from damage.
6. If required, furnish commercial grade, minimum 8 foot high chain link fence around construction Site. Equip with vehicular gates with locks.

B. Protection of Work

1. Protect Work during working and non-working hours.
2. Provide special protection where specified in Specifications or Drawings and in accordance with manufacturer recommendations.
3. Furnish temporary and removable protection for installed equipment and material. Control activity in immediate Work area to minimize damage.
4. Protect exterior areas of Work from damage. Prohibit traffic from landscaped areas.
5. Buildings and Enclosures
  - a. Furnish protective coverings at walls, projections, jambs, sills, and soffits of openings and protect finished floors, stairs, and other surfaces from traffic, dirt, wear, damage, or movement of heavy objects, by protecting with durable sheet materials.
  - b. Prohibit traffic or storage upon waterproofed or roofed surfaces. If traffic or activity is necessary, obtain recommendations for protection from waterproofing or roofing material manufacturer.
6. Whenever gale or high winds are forecast, take measures to secure loose material, equipment or other items that could be blown and be damaged or cause damage. Do not leave such loose items unsecured at end of a working day. Particular attention shall be taken with scaffolding and items placed or stored on roofs or within a structure prior to being enclosed.
7. Provide for removal of snow and ice which may impede Work, damage the finishes or materials, be detrimental to workers, or impede trucking, delivery, or moving of materials at the Site, or prevent adequate drainage of the Site or adjoining areas.

C. Security

1. Provide protection to stored items, the Work and Owner's operations from unauthorized entry, vandalism, or theft, and against fire, storms and other losses during working and non-working hours.
2. Coordinate with Owner's security program.

D. Safety Facilities

1. Provide first aid and other safety facilities required by Laws and Regulations during working and non-working hours.

- E. Access Roads
  - 1. Construct and maintain temporary roads accessing public thoroughfares to serve construction area. Control dust and water.
  - 2. Extend and relocate as Work progress requires. Provide detours necessary for unimpeded traffic flow.
  - 3. Provide for emergency access and maintain throughout the Work Site.
- F. Parking
  - 1. Construct temporary gravel surface parking areas to accommodate construction personnel. When Site space is inadequate, provide for off-Site parking.
  - 2. Do not allow construction vehicle parking on existing pavement or sidewalks.
- G. Field Offices – furnish as required.
- H. Progress Cleaning and Waste Removal
  - 1. Maintain areas free of waste materials, debris, and rubbish and maintain the Site in a clean and orderly condition.
  - 2. Remove debris and rubbish from spaces and other closed or remote spaces before enclosing the space.
  - 3. Collect and remove waste materials, debris, and rubbish from Site at least weekly and legally dispose off-Site.

### **3.02 TEMPORARY UTILITIES**

- A. Arrange for, pay for and maintain suitable utilities as required for duration of Project.
- B. Furnish lighting for construction operations. Furnish lighting for exterior staging and storage areas and for security purposes. Maintain lighting and provide routine repairs.
- C. Furnish and pay for heat devices and heat and cooling devices as required to maintain specified conditions for construction operations.
- D. Ventilate enclosed areas to assist cure of materials, to dissipate humidity, and to prevent accumulation of dust, fumes, vapors, or gases.
- E. Furnish and maintain required sanitary facilities and enclosures. Do not use existing facilities.

F. Fire Protection

1. Provide temporary fire protection equipment and services during construction until the permanent system is serviceable per NFPA and local fire code and regulations, and fire marshal's requirements.
2. Use Work procedures that minimize fire hazards to the extent practicable and materials that are fire resistant where possible. Collect and remove combustible debris and waste materials from the Site each day. Store fuels, solvents, and other volatile or flammable materials away from the construction and storage areas in well-marked, safe containers in accordance with Laws and Regulations.

**3.03 TEMPORARY CONTROLS**

- A. Pest Control: Provide methods, means, and facilities to control and prevent spread of pests during construction operations. If required, provide for extermination of pests in accordance with Laws and Regulations. For extensive infestations, obtain the services of a licensed exterminator and coordinate plan with Owner and Engineer.
- B. Dust Control: Execute Work by methods to minimize raising dust from construction operations. Provide positive means to prevent air-borne dust from dispersing into atmosphere. Utilize the application of sprinkled water to reduce the emission of air-borne soil particulates from the Project Site.
- B. Noise Control
1. Provide methods, means, and facilities to minimize noise from construction operations.
  2. Provide noise attenuation systems capable of meeting the Department of Environmental Protection Division of Air Quality Control regulations governed by the following policy:

*"A source of sound will be considered to be violating the Department's noise regulation (310 CMR 7.10) if the source:*

- *Increases the broadband sound level by more than 10 dB(A) above ambient, or*
- *Produces a "pure tone" condition when any octave band center frequency sound pressure level exceeds the two adjacent center frequency sound pressure levels by 3 decibels or more.*

*"These criteria are measured both at the property line and at the nearest inhabited residence. Ambient is defined as the background A-weighted sound level that is exceeded 90% of the time measured during equipment operating hours. The ambient may also be established by other means with the consent of the Department."*

3. Construct sound enclosures or utilize other noise reduction techniques if the equipment does not meet the noise level requirements.

C. Pollution Control

1. Provide methods, means, and facilities to prevent contamination of soil, water, and atmosphere from discharge of noxious, toxic substances, and pollutants produced by construction operations.

a. Water Pollution Control

- 1) Assure that sediment, debris, petroleums, chemicals, or other contaminants will not enter existing drainage facilities and channels. Use construction methods that will prevent entrance of pollutants and wastes into existing streams, rivers, lakes, and flowing and dry watercourses.
- 2) Obtain legal disposal sites and dispose of pollutants and wastes in a legal manner.
- 3) Respond immediately to emergencies as directed when water quality of existing streams, rivers, lakes and flowing and dry watercourses is threatened. Take corrective action to remove or contain pollutants until a permanent solution is determined.

b. Air Pollution Control

- 1) Equipment and vehicles that exhibit excessive exhausts emissions due to poor engine adjustments or inefficient operation will not be permitted to operate until corrective repairs or adjustments are made.
- 2) Burning of materials from clearing or grubbing operations, combustible construction materials, and rubbish will not be allowed.

### **3.04 REMOVAL OF TEMPORARY UTILITIES, FACILITIES, AND CONTROLS**

- A. Remove temporary utilities, equipment, and facilities before Final Application for Payment inspection.
- B. Remove temporary underground installations and grade Site as indicated. Clean and repair damage caused by installation or use of temporary utilities, facilities, and controls.
- C. Restore existing facilities and areas used during construction to original condition. Restore permanent facilities used during construction to specified condition.

### 3.05 OVERALL EXECUTION REQUIREMENTS

#### A. Coordination

1. Conduct preconstruction and pre-installation meetings before commencing certain Work that requires coordination or has special requirements or approvals in accordance with Paragraph 1.03.A above.
2. Coordinate space requirements and installation of Work. Utilize spaces efficiently to maximize accessibility for other installations, maintenance, and repairs.
3. Coordinate Work of the various Specifications with interdependent responsibilities for installing, connecting to, and placing in service, operating equipment.
4. Coordinate related Work at the Site.
5. Coordinate completion and cleanup of Work of separate sections in preparation for Substantial Completion and for portions of Work designated for Owner's partial occupancy.
6. After Owner occupancy of premises, coordinate access to Site for correction of defective Work and/or incomplete Work to minimize disruption of Owner's activities.
7. Coordinate Work such that Work on each street is completed with minimum disruption to residents and businesses.

#### B. Existing Conditions

1. Availability of Lands
  - a. No easements and rights-of-way exist for the Project.
2. Subsurface and Physical Conditions
  - a. Existence and location of Underground Facilities and other utilities and construction indicated as existing are not guaranteed. Before beginning Work investigate and verify the existence and location of Underground Facilities and other utilities and construction.
  - b. The following reports of explorations and tests of subsurface conditions at or contiguous to the Site are known to Owner:

NONE

The following drawings of physical conditions relating to existing surface or subsurface structures at the Site (except Underground Facilities) are known to Owner:

NONE

C. Record Documents

1. Contractor shall maintain in a safe place at the Site one record copy of all Drawings, Specifications, Addenda, Change Orders, Work Change Directives, Field Orders, and written interpretations and clarifications in good order and annotated to show changes made during construction. These record documents together with all approved Samples and a counterpart of all approved Shop Drawings will be available to Engineer for reference. and submitted at final completion per Paragraph 1.03.D above.
2. Store Record Documents separate from documents used for construction. Record information concurrent with construction progress.
3. Legibly mark each item to record description of actual equipment and material installed and actual construction on approved submittals, including the following.
  - a. Manufacturer's name and equipment and material model and number
  - b. Material and equipment substitutions or alternates utilized
  - c. Approved changes
  - d. Measured depths of foundations
  - e. Measured horizontal and vertical locations of Underground Facilities and appurtenances, referenced to permanent surface improvements
  - f. Measured locations of internal utilities and appurtenances concealed in construction, referenced to visible and accessible features of the Work
  - g. Field changes of dimension and detail
  - h. Details not on original Contract Documents or Shop Drawings
4. Submit final record documents as specified in Paragraph 1.03.D above in accordance with subparagraph 1.03.C.8. above. Engineer's review of the final Application for Payment and accompanying documentation and all maintenance and operating instructions, schedules, guarantees, bonds, certificates of inspection, tests and approvals, and other documentation required to be delivered at final completion will be only be to determine generally that the content complies with the requirements of, and in the case of certificates of inspections, tests and approvals, that the results certified indicate compliance with, the Contract Documents.

D. Cutting and Patching

1. Employ skilled and experienced personnel to perform cutting and patching.
2. Submit written request in advance of cutting or alteration which affects:
  - a. structural integrity of any element of Project;
  - b. integrity of weather exposed or moisture resistant elements;
  - c. efficiency, maintenance, or safety element;
  - d. safety, traffic, or hazard barriers;
  - e. visual qualities of sight exposed elements; and
  - f. work of Owner or separate contractor.
3. Execute cutting, fitting, and patching including excavation and fill to complete Work and to:
  - a. fit materials together, to integrate with other work;
  - b. uncover Work to install ill-timed Work;
  - c. remove and replace defective or non-conforming Work;
  - d. remove Samples of installed Work for testing when requested; and
  - e. provide openings in element of Work for penetration of mechanical and electrical work.
4. Execute Work by methods to avoid damage to other work and which will provide appropriate surfaces to receive patching and finishing.
5. Provide adequate temporary support for Work to be cut.
6. Restore Work with new materials in accordance with requirements of Contract Documents. Use materials identical with original materials where recognized that satisfactory results can be produced.
7. Provide protection from elements for areas which may be exposed by uncovering work.
8. Refinish surfaces to match adjacent finishes. For continuous surfaces, refinish to nearest intersection or natural break. For an assembly, refinish entire unit. Restore exposed finishes of patched areas; and, where necessary extend finish restoration onto retained adjoining Work in a manner, which will eliminate evidence of patching.
9. Identify any Hazardous Waste, Hazardous Environmental Condition, or hazardous substance exposed during the Work to Owner for decision or remedy .
10. Cut work by methods least likely to damage Work to be retained and work adjoining. Cut Work with sawing and grinding tools, not with hammering,

chopping, or burning tools. Cut masonry and concrete materials with masonry saw or core drill. Do not use pneumatic tools without prior approval. Core drill openings through concrete Work. Adhere to mandatory cutback requirements when saw cutting concrete and roadway openings.

11. Do not cut and patch structural Work in a manner resulting in reduction of load-carrying capacity or load/ deflection ratio.
12. Fit Work tight to pipes, sleeves, ducts, conduit, and other penetrations through surfaces. Maintain supports to ensure structural integrity of the Work. Provide devices and methods to protect other portions of Project from damage and seal voids. For interior work at penetrations of fire rated walls, partitions, ceiling, or floor construction, completely seal voids with fire resistant material, to full thickness of the penetrated element.
13. Do not cut and patch operational or safety-related components that reduce capacities to perform in manner intended. Do not cut and patch Work that reduces visual qualities. Remove and replace unsatisfactory cutting patching as directed by Engineer or Owner.

E. Electrolytic Corrosion Prevention

1. Prevent galvanic action, bimetallic corrosion, anodic or cathodic action, and electrolysis at all electrical grounds and for all galvanic scale (electromotive series or table of oxidation potentials). Do not allow contact of dissimilar metals further apart than 0.35 on the galvanic scale (electromotive series or table of oxidation potentials). The electrode potential of common metals is listed below.

|                | Electrode Potential Volts<br>(Relative to Hydrogen) |
|----------------|-----------------------------------------------------|
| Magnesium      | +2.37                                               |
| Aluminum       | +1.70                                               |
| Zinc+          | +0.76                                               |
| Chromium       | +0.56                                               |
| Iron and Steel | +0.44                                               |
| Cadmium        | +0.40                                               |
| Nickel         | +0.25                                               |
| Tin            | +0.14                                               |
| Lead           | +0.13                                               |
| Copper         | -0.34                                               |

2. Unless otherwise indicated, provide dielectric insulators between ferrous and nonferrous pipe and equipment.

F. Quality Assurance and Control of Installation

1. Monitor quality control of Subcontractors, Suppliers, manufacturers, material, equipment, services, Site conditions, and workmanship, to

produce Work of specified quality. Conduct field quality control and testing specified.

2. Comply fully with manufacturers' installation instructions, including each step in sequence. If manufacturers' instructions conflict with Contract Documents, request clarification from Engineer before proceeding.
3. Comply with specified standards as a minimum quality for the Work except when more stringent tolerances, codes, or specified requirements indicate higher standards or more precise workmanship.
4. Perform Work using persons qualified to produce workmanship of specified quality.
5. Install field Samples and mockups at the Site as required in Specifications for review. Acceptable Samples and mockups represent a quality level for the Work. Where field Sample or mockup is specified to be removed, clear area after field Sample or mockup has been accepted by Engineer or after Work is complete when mockup is to serve as a control reference.
6. Protect adjacent construction.

G. Manufacturers' Field Services

1. If required in the Specifications, arrange and pay for material or equipment Suppliers or manufacturers to provide qualified staff personnel (field representative) to perform the following services and services specified. Submit reports of activities, actions taken and test results to Engineer within 10 days of completion in accordance Paragraph 1.03.C above.
  - a. Observe Site conditions, conditions of surfaces and installation, quality of workmanship.
  - b. Report observations and Site decisions or instructions given to applicators or installers that are supplemental or contrary to manufacturers' written instructions.
  - c. Assist with field assembly as required.
  - d. Furnish, setup, and operate required test equipment and facilities.
  - e. Perform and record results of manufacturer recommended inspections and tests, and tests specified for material and equipment.
  - f. Be responsible for protection of material and equipment and safety of all personnel during testing.
  - g. Perform any other services normally provided by field representative's company.
  - h. Instruct operating personnel in proper use of material and equipment.

H. Independent Testing

1. Employ and pay for specified services of an independent to perform inspection and testing as may be specified.
2. Reports will be submitted by the independent firm to Owner, in duplicate indicating observations and results of tests and indicating compliance or noncompliance with Contract Documents.
3. Inspection, testing, and source quality control may occur on or off the Project Site.
4. Cooperate with independent firm. Furnish samples of materials, design mix, equipment, tools, storage and assistance as requested.
5. Notify Owner and independent firm 24 hours before expected time for operations requiring services.
6. Make arrangements with independent firm and pay for additional Samples and tests required for Contractor's use.
7. Retesting required because of nonconformance to specified requirements will be performed by the same independent firm if instructed by Owner. Payment for retesting will be charged to Contractor by deducting inspection or testing charges from the Contract Price.
8. Testing or inspecting does not relieve Contractor from performing Work in accordance with requirements of the Contract Documents.

**3.06 STARTUP, TESTING, AND COMMISSIONING**

A. Spare Parts

1. Provide spare parts required for construction, startup, testing and commissioning of the Work prior to achievement of Substantial Completion, including spare parts for flushing and consumable supplies such as bolts, nuts, gaskets, filters, insulating tape, etc., normally consumed in the construction, commissioning and testing.
2. If spare parts are purchased by Owner, Contractor shall have the right to use the spare parts purchased by Owner provided that such spare parts are replaced prior to Substantial Completion at Contractor's expense. Replacement spare parts, replaced by Contractor, shall be new, unused and identical as the original spare part used.

B. Consumables

1. Provide initial fills of consumables including equipment lubricants, resins, chemicals, desiccants, and fuels. Provide subsequent fills if required during Warranty Period if acts or omissions of Contractor cause such consumables to require replacement.
  2. Coordinate with Owner for consumables required.
- C. Checkout and Starting Systems
1. Coordinate schedule for startup and operation of various equipment and systems with Owner.
  2. Notify Owner 7 days before startup of each major piece of equipment or system, including a staffing request for Owner's operations and maintenance personnel required to adequately and safely support each specific start-up and operation activity.
  3. Verify that each system or piece of equipment item has been assembled, constructed, or completed in accordance with the Contract and capable of functioning as intended.
  4. Verify that each piece of equipment or system has been checked for proper lubrication, drive rotation, magnetic center alignment, belt tension, control sequence, or other conditions which may cause damage.
  5. Verify that each piece of equipment or system has successfully completed construction testing and cold commissioning, including hydrostatic testing, loop checks, relay checks, calibration, and continuity checks and that all tests, meter readings, and specified electrical characteristics agree with those required by the equipment or system manufacturer.
  6. Verify wiring and support components for equipment are complete and tested.
  7. Execute start up under supervision of responsible manufacturers' representative or Contractor's personnel in accordance with manufacturers' instructions utilizing Owner's qualified operations and maintenance staff trained by Contractor.
  8. When specified in individual Specification Sections, require manufacturer to provide field representative to be present at Site to inspect, check and approve equipment or system installation before start up, and to supervise placing equipment or system in operation.
- D. Starting, Adjusting, and Balancing
1. Supply necessary equipment, material, construction power, and consumables (except for those provided by Owner) needed to startup and

fully test the Work and replenish the same until Substantial Completion is achieved. Contractor may utilize Owner's operating spare parts, such use requiring timely replacement at Contractor's expense.

2. Coordinate as required for conduct of independent testing.
3. Perform specified and required adjusting and balancing concurrently to the maximum extent possible on individual equipment and systems and prior to startup and commissioning/performance testing.

E. Startup and Commissioning/Performance Testing

1. Conduct startup and commissioning/performance tests to demonstrate the Work meets the requirements of the Contract Documents, satisfies the Owner's requirements. Conduct testing in accordance with individual Specifications and Section 01 91 15 Startup, Commissioning and Testing.
2. Prepare and submit a written startup and commissioning/performance testing procedures no later than 60 days prior to start of testing for review and final test procedures no later than 30 days prior to start of testing. Submit a staffing request for Owner's operations and maintenance personnel.
3. Calibrate test equipment and instrumentation on Site or provide acceptable certificate of calibration conducted within 30 days of testing.
4. Complete functional testing prior to initiating the startup and commissioning/performance testing as specified.
5. Complete specified startup and commissioning/performance tests prior to Substantial Completion. Owner and Engineer will witness Performance Testing. Notify Owner and Engineer in writing at least 7 days prior to starting any startup and commissioning/performance testing. Coordinate for witnessing of tests by required regulatory representatives.
6. Submit written test reports per subparagraph 1.03.C.7.b and Paragraph 1.03.D above.

F. Demonstration and Training

1. Provide formal demonstration and training of Owner's personnel as specified in individual Specification sections.

**END OF SECTION**

## **SECTION 01 15 20**

### **MAINTAINING OPERATIONS**

#### **PART 1 – GENERAL**

##### **1.01 SUMMARY**

- A. The City of Worcester's Water Filtration Plant is operated 24 hours a day, 7 days per week and must be maintained in continuous operation by the Owner at all time during the entire construction period unless previously coordinated with the Owner.
  - 1. Schedule and conduct Work to avoid disrupting any safety or emergency systems, typical function of the plant, and the disinfection processes, as well as creating potential hazards to operating equipment and/or personnel and reducing the quality of the plant effluent.
  - 2. Coordinate any necessary shutdowns with the Owner.
  - 3. Ensure construction schedule is compatible with the facility operations.
- B. Related Requirements
  - 1. Section 01 50 00 – Temporary Facilities and Controls
  - 2. Section 01 91 15 – Startup and Commissioning

##### **1.02 PRICE AND PAYMENT PROCEDURES**

- A. Measurement and payment requirements: per Division 01 General Requirements.

##### **1.03 ADMINISTRATIVE REQUIREMENTS**

- A. Coordination, sequencing, and scheduling: per Division 01 General Requirements.

##### **1.04 SUBMITTALS**

- A. Submit in accordance with Division 01 General Requirements.
- B. The Contractor shall at all times conduct their operations so to minimize interference with existing works. The Contractor shall develop a sequence of operation, in cooperation with the Engineer and Owner, which shall provide for the orderly construction and start-up of the new works. Within 30 calendar days of the Notice to Proceed, submit complete descriptions of procedures to maintain plant operation to supplement the construction schedule, including the following.
  - 1. Step-by-step procedures, required durations, and specific procedures required to be performed by the Contractor as well as assistance from the

Owner's personnel that the Contractor will request. Include a minimum 2-week notification to the Owner for any alterations that affect operation of the treatment facility. Coordinate with the Owner again 7 days before and on the day of such alterations.

## **1.05 QUALITY ASSURANCE**

- A. Provide in accordance with Division 01 General Requirements.

## **1.06 SITE CONDITIONS**

- A. Existing Conditions: per Division 01 General Requirements.
- B. Unless permitted in writing by the Owner and Engineer, construction activities shall not reduce the treatment capability of the plant. The treatment capability of the plant refers to all portions of water treatment including the treatment processes directly impacted by this Work.
- C. Owner will continue to operate the treatment plant during the construction period. The Contractor shall be required to fully cooperate with the Owner, coordinate the construction schedule with the Owner and Engineer, and provide the necessary labor, equipment and materials to prevent interruption to flow or the treatment process.

## **PART 2 – PRODUCTS (NOT USED)**

## **PART 3 – EXECUTION**

### **3.01 WORK DURING LOW FLOW CONDITIONS**

- A. Follow the proposed Work sequence at such times that are acceptable or agreed to by the Owner. Any construction activity specified to be performed during a low flow period shall meet the following criteria.
  - 1. Low influent flow periods are defined as early weekday and weekend mornings (between 8:00 p.m. and 4:00 a.m.), during dry weather periods only. Overtime Work to conform to these requirements shall be considered as normal procedure at no additional cost to Owner.

### **3.02 SEQUENCING AND COORDINATION WITH PLANT OPERATIONS**

- A. Sequence Work to achieve Project objectives, maintain plant operations, and maintain compliance with discharge permit requirements. Refer to Section 01 11 00 for detailed sequencing and coordination requirements.
- B. Plan Work connecting with, cutting into, and reconstructing existing pipes or structures to minimize interference with the operation of the existing facilities and when the demands on the facilities best permit such interference, working outside of normal working hours to meet these requirements if necessary.

- C. Before starting Work which will interfere with the operation of existing facilities, conduct preparatory Work and ensure labor, tools, materials, and equipment are made ready. Assist in instructing operations and maintenance personnel in any new operating procedures.
- D. Provide, maintain, and operate all necessary temporary facilities.
  - 1. Do not allow flow to and through the treatment facility to be interrupted except for flow through portions of the plant where Work is to be performed. Shut downs shall occur only upon written request and with prior written authorization from the Owner. Such authorizations will be limited to times when the hydraulic capacity of units remaining in service are not be exceeded.
- E. When Work requires that a portion of the plant be shut down, execute Work expeditiously. Plan the Work, taking into consideration potential problems. Provide that spare pumps, pipe and fittings, and any other equipment are readily available for use in an emergency. Be prepared to Work continuously (24 hours per day, 7 days per week) during the time when any units or pipelines are out of service that affect the treatment process.
- F. Maintain road access to all areas of the plant Site at all times.

**END OF SECTION**

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## SECTION 01 91 15

### STARTUP AND COMMISSIONING

#### PART 1 – GENERAL

##### 1.01 SUMMARY

- A. Section Includes
  - 1. Startup and commissioning of the mechanical process, electrical, ventilation, and instrumentation systems required for full and complete water booster pump skid operation, including SCADA connections from water booster pump skid to Owner's existing control panel.
- B. A system is defined as an arrangement of items of equipment, components, piping, wiring, materials, or incidentals so related or connected as to form a functional and operational unit.

#### PART 2 – PRODUCTS (NOT APPLICABLE)

#### PART 3 – EXECUTION

##### 3.01 SYSTEM STARTUP & DEMONSTRATION REQUIREMENTS

- A. Pre-Startup Requirements
  - 1. Prior to startup, undertake the following procedures, in the order listed.
    - a. Ensure required written statements and/or guarantees from manufacturers of individual Specification sections comply with Contract Documents. Use a checklist to identify such requirements, by Specification section and submit a copy of completed checklist to the Engineer with manufacturers' written statements and/or guarantees.
    - b. Ensure Work is complete before startup of any unit or system. Certify to Owner that specifically services or respective equipment manufacturers' representative required by individual Specifications have been performed in accordance with Contract Documents.
    - c. Ensure systems are tested hydraulically, mechanically, and electrically. Ensure systems requiring calibration, commissioning, and balancing are fully certified as complete in performance in accordance with Contract Documents. Ensure required tagging, identification, and stenciling is complete.
    - d. Disinfect piping prior to startup and commissioning per Section 33 01 10.58.

- e. Schedule startup a minimum of 30 days prior, with written notice issued, but not limited to: Owner, Engineer, Subcontractors, and applicable regulatory agencies.
- f. Provide labor, supervision, utilities, chemicals, equipment, tools, materials, vehicles and other items necessary to startup, operate, and demonstrate the system.
- g. Provide gauges, meters, recorder and monitors as required by the Engineer to supplement or augment the instrumentation system provided under this Contract to properly demonstrate that equipment fully satisfies the requirements of the Contract Documents. Select specific devices employed for the purpose of measuring the performance of the facility's equipment and systems to provide a level of certainty consistent with the variables to be monitored. Provide that instruments are recently calibrated, and be prepared to demonstrate, through recalibration, the certainty of instruments employed for testing purposes. Perform calibration procedures per applicable standards of ASTM, ISA and IEEE. The adequacy of gauges, meters, recorders and monitors are subject to review of the Engineer.
- h. Provide sign off forms for each item of mechanical, electrical and instrumentation equipment provided or installed and include provisions for recording relevant performance data for original testing, and not less than 3 retests. Provide separate sections on the form to record values for pre-operation checkout, initials of representatives of equipment manufacturers, Contractor and Engineer.
- i. Maintain a master file of equipment sign off forms and make available for inspection by the Engineer. Upon completion of equipment testing, submit the original and two copies of the sign off forms for each equipment item.

**B. System Startup and Demonstration**

- 1. Startup, operate and demonstrate specified performance of each item of equipment and each system at full operation without interruption of equipment or system or need of adjustment or repair to the satisfaction of the Engineer.
- 2. During startup of equipment, provide knowledgeable and experienced person(s) to instruct Owner's designated personnel on the operation and maintenance of each system in addition to services provided by equipment manufacturer's authorized representative(s) prescribed by individual Specifications. Provide instructions during the startup period in the form of a comprehensive "overview"; do not simply repeat previous operation and maintenance instructions. Provide a minimum of three hours of operation and maintenance instructions on each system per the Specifications.

### 3.02 EQUIPMENT STARTUP & PERFORMANCE TEST PROTOCOL

- A. Conduct startup in the following order.
  - 1. Equipment Pre-Startup Check
  - 2. Equipment Startup and Performance Testing
  - 3. Manufacturers' Equipment Testing
- B. Equipment Pre-Startup
  - 1. Check out each item of equipment in the presence of the Engineer to demonstrate proper installation, functioning and ready for equipment startup and performance testing.
  - 2. Minimum requirements include, but are not limited to, the following.
    - a. Coordinate with Owner's electrical and SCADA contractors for connections, terminations and controls as required.
    - b. Ensure equipment is properly installed, painted, leveled, wired and/or insulated.
    - c. Ensure piping is properly installed and valving is properly set.
    - d. Ensure piping is cleaned and pressure tested, as required.
    - e. Ensure equipment is properly lubricated.
    - f. Ensure safety related accessories are properly installed.
    - g. Bump or momentarily jog equipment to establish operation and proper rotation.
  - 3. Arrange for equipment manufacturers to be present, or verify that these procedures may be done without the manufacturer's representatives being present.
- C. Equipment Startup
  - 1. Prior to testing any equipment, obtain written certification from the manufacturer that the equipment is properly installed, calibrated and ready for safe and efficient operation as intended by the Engineer and manufacturer.
  - 2. Thoroughly clean and flush equipment and associated piping, channels, basins, and wetwells prior to startup and testing of any item of equipment.
  - 3. Startup and operate each item of equipment, with assistance from the manufacturer's factory trained service engineer and in the presence of the Engineer, to demonstrate equipment performs according to the requirements of the Specifications to ensure equipment is ready for performance testing.
- D. Performance Tests
  - 1. General

- a. Coordinate with Owner's electrical and SCADA contractors for performance testing.
  - b. Make full tests at the Site on each item of equipment after it has been properly installed, started and certified ready for operation to demonstrate that each item of equipment will operate properly by itself and in conjunction with other facility equipment in accordance with the Specifications.
  - c. Furnish necessary labor, tools, equipment, power, chemicals and clean water, to perform field tests to determine that the supplied equipment, including controls and alarms, meet hydraulic, electric mechanical and performance requirements in accordance with the Specifications.
  - d. Repeat incomplete and/or unsuccessful tests to the satisfaction of the Engineer.
2. Pumps
- a. Determine maximum pumpage.
  - b. Ensure pump rate falls on pump curves.
  - c. Record the following readings on each pump.
    - 1) Test Flow Rate and TDH during Test
    - 2) Amperes per phase, at the Test Flow Rate and TDH
    - 3) Voltage each phase, at the Test Flow Rate and TDH
    - 4) HP input to motor, at the Test Flow Rate and TDH
  - d. Determine efficiency of pumping units at test and design conditions.
  - e. Record maximum ampere and voltage readings of each motor and determine that they compare to the nameplate data.
  - f. Verify proper operation of valves.
  - g. Verify pump speed.
3. Process Equipment, Instrumentation, and Controls
- a. Calibrate and/or verify calibration and proper operation and function of all process and analytical instruments, and documents results, for the following.
    - 1) Flow measurement
    - 2) Indicating controllers
    - 3) Indicators
    - 4) Miscellaneous equipment
4. Electrical
- a. Coordinate with Owner's electrical contractor to verify proper operation and function of electrical equipment and instruments, and document results, for the following.

1) Variable Frequency Drives

5. SCADA

- a. Coordinate with Owner's SCADA contractor to calibrate and/or verify proper operation and function of all SCADA equipment and document results.

E. Manufacturers' Training

1. Comply with requirements in Specifications for manufacturers' training.
2. No training can be conducted until the Owner has received approved manufacturers' operation & maintenance manuals.
3. Owner will not accept any item of equipment prior to receiving approved manufacturer training for the equipment. This applies only to equipment requiring manufacturers' training in accordance with the Specifications.
4. Conduct training in addition to and exclusive of startup and performance testing.
5. Engineer shall approve the completeness of training and provide written verification of manufacturers' equipment training.

**END OF SECTION**

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## SECTION 03 01 05

### CONCRETE REPAIR

#### PART 1 – GENERAL

##### 1.01 SUMMARY

A. Section Includes

1. Repair deteriorated concrete areas indicated on Drawings and in accordance with this Section and applicable reference standards listed in Article 1.03.

##### 1.02 PRICE AND PAYMENT PROCEDURES

- A. Measurement and payment requirements: per Division 01 General Requirements.

##### 1.03 REFERENCES

A. Reference Standards

1. American Association Of State Highway And Transportation Officials (AASHTO)
  - a. AASHTO T 277 Standard Method of Test for Electrical Indication of Concrete's Ability to Resist Chloride Ion Penetration
2. ASTM International (ASTM)
  - a. ASTM C78 Standard Test Method for Flexural Strength of Concrete (Using Simple Beam with Third-Point Loading)
  - b. ASTM C109 Standard Test Method for Compressive Strength of Hydraulic Cement Mortars (Using 2-in. or (50-mm) Cube Specimens)
  - c. ASTM C496 Standard Test Method for Splitting Tensile Strength of Cylindrical Concrete Specimens
  - d. ASTM C882 Bond Strength of Epoxy-Resin Systems Used with Concrete by Slant Shear
  - e. ASTM C884 Thermal Compatibility between Concrete and Epoxy-Resin Overlay
  - f. ASTM C1202 Standard Test Method for Electrical Indication of Concrete's Ability to Resist Chloride Ion Penetration

- g. ASTM G109 Determining the Effects of Chemical Admixtures on the Corrosion of Embedded Steel Reinforcement in Concrete Exposed to Chloride Environments

#### **1.04 ADMINISTRATIVE REQUIREMENTS**

- A. Coordination, sequencing, and scheduling: per Division 01 General Requirements.

#### **1.05 SUBMITTALS**

- A. Submit in accordance with Division 01 General Requirements.
- B. Product Data
  - 1. Trowel-grade polymer modified Portland cement repair mortar
  - 2. Non-sag polymer modified Portland cement repair mortar
  - 3. Reinforcing steel primer
- C. Notarized certificate stating that repair material meets the specified requirements and the manufacturer's current printed product literature.
- D. Closeout and maintenance material submittals: per Division 01 General Requirements.

#### **1.06 QUALITY ASSURANCE**

- A. Provide in accordance with Division 01 General Requirements.

#### **1.07 DELIVERY, STORAGE, AND HANDLING**

- A. Provide in accordance with Division 01 General Requirements.
  - 1. Deliver products in original, unopened containers with the manufacturer's name, labels, product identification, and batch numbers.
  - 2. Store in accordance with manufacturer recommendations.

#### **1.08 SITE CONDITIONS**

- A. Existing conditions: per Division 01 General Requirements.
  - 1. Take precautions to avoid damage to surface due to mixing and handling of specified repair material near area of Work.

## 1.09 WARRANTY

- A. Provide 3-year extended correction/warranty period for repair Work covering full labor and materials during the warranty period as required to repair/replace any defects or failures observed for specified repair items. Warranty failure: sealant cracking, disbonding, splitting, or other visible defects; spall repair spalling, cracking, delaminating (hollow from hammer sounding), or other visible or disbonding defects; leakage or weeping of injection crack repairs.

## PART 2 – PRODUCTS

### 2.01 MORTAR

- A. Comply with applicable reference standards listed in Article 1.03.
- B. Performance/Design Criteria
  - 1. Mixed Properties
    - a. Application time: approximately 15 minutes.
    - b. Finishing time: 20-60 minutes.
    - c. Color: concrete gray.
  - 2. Cured Properties
    - a. Compressive Strength (ASTM C109)
      - 1) 1 day: 3,000 psi minimum.
      - 2) 28 day: 7,000 psi minimum.
    - b. Splitting Tensile Strength (ASTM C496)
      - 1) 28 day: 750 psi minimum
    - c. Flexural Strength (Modulus of Rupture, ASTM C78)
      - 1) 28 day: 2,000 psi minimum.
    - d. Bond Strength (ASTM C882)
      - 1) 28 day: 2,200 psi minimum.
    - e. Thermal Compatibility (ASTM C884)
      - 1) Passes test
    - f. Permeability (ASTM C1202, AASHTO T 277)

- 1) 28 day: approximately 500 coulombs.
- g. Cracked Beam Corrosion Tests (ASTM G109)
  - 1) Reduced corrosion rates: 63 percent versus control specimens.
- C. Acceptable level of quality: equivalent to products manufactured by Sika Corporation meeting specified performance requirements.
  1. Trowel-grade mortar for horizontal surfaces: SikaTop 122 Plus.
  1. Non-sag mortar for vertical and overhead surfaces: SikaTop 123 Plus.
  2. Steel reinforcement primer: Sika Armatec 110 EpoCem.

## **2.02 SOURCE QUALITY CONTROL**

- A. Provide in accordance with Division 01 General Requirements. Comply with applicable reference standards listed in Article 1.03.

## **PART 3 – EXECUTION**

### **3.01 GENERAL**

- A. Comply with applicable reference standards listed in Article 1.03.
- B. Do not apply material in inclement weather or if inclement weather is imminent.
- C. Condition product as recommended by manufacturer.

### **3.02 SURFACE PREPARATION**

- A. Mechanically prepare areas to be repaired so they are clean, sound and free of contaminants. Remove loose and deteriorated concrete by mechanical means. Remove dirt, oil, grease, and bond-inhibiting materials from the surface.
- B. Except where tie holes are filled, saw cut perimeter 1/8 inch minimum when a neat mortar is to be applied, and 1-inch minimum when an extended mortar is to be applied.
- C. Prepare concrete substrate to obtain a minimum surface profile of 1/16 inch in depth with a new aggregate fractured surface using steel shot blasting, abrasive blasting, or water jetting. Do not use scabblers, bush hammers, or pneumatic hammers. Provide that the area to be repaired is not less than 1/8 inch in depth.
- D. Prepare substrate to saturated surface dry condition with no standing water.
- E. Steel Reinforcement Primer

1. Where reinforcement with active corrosion is encountered, sandblast to remove contaminants and rust, pressure wash, and apply primer.
  2. Determine section loss and splice new reinforcement where there is more than 15 percent to 25 percent loss, as directed by Engineer. If half or more of the diameter of the bar is exposed, chip out 1/2 inch minimum behind the bar.
- F. Treat cracks in the substrate in the area of repair as directed by Engineer.

### 3.03 MIXING AND APPLICATION

- A. Mix and apply in strict accordance with manufacturer's instructions and adhere to limitations and cautions.
- B. Trowel-Grade Polymer Mortar
1. Pour entire Component A into mixing container. Add entire Component B while mixing. For extended mix, introduce 3/8-inch coarse aggregate at desired quantity. Mix to uniform consistency, maximum 3 minutes.
    - a. Addition rate not to exceed 42 pounds per bag.
    - b. Aggregate: non-reactive, clean, well-graded, saturated surface dry, with low absorption/high density.
  2. Scrub mortar into substrate, filling pores and voids. Force material against edge of repair, working toward center. After filling repair, consolidate, then screed. Allow mortar or concrete to set to desired stiffness and finish with wood or sponge float for a smooth surface.
    - a. Minimum application thickness: 1/8-inch for a neat mortar; 1 inch if extended.
    - b. Maximum application thickness in a single lift: 1 inch for a neat mortar; 3 inches if extended.
    - c. Where multiple lifts are required, score top surface of the preceding lift to produce a roughened surface. Allow preceding lift to reach final set prior to applying the next lift.
- C. Non-Sag Polymer Mortar
1. Pour entire Component A into mixing container. Add entire Component B while mixing. Mix maximum 3 minutes to uniform consistency.
  2. Scrub mortar into substrate, filling pores and voids. Force material against edge of repair, working toward center. After filling repair, consolidate,

then screed. Allow mortar or concrete to set to desired stiffness and finish with wood or sponge float for a smooth surface.

- a. Minimum application thickness: 1/8-inch.
- b. Maximum application thickness in a single lift: 1-1/2 inches.
- c. Where multiple lifts are required, score top surface of preceding lift to produce a roughened surface. Allow preceding lift minimum 30 minutes to reach final set prior to applying the next lift.

D. Curing

1. Moist cure with wet burlap and polyethylene using a fine mist of water or water based compatible curing compound. Do not use curing compounds for curing between successive lifts. Do not use solvent-based curing compounds. Commence moist curing immediately after finishing. Protect newly applied material from direct sunlight, wind, rain, and frost.

**3.04 FIELD QUALITY CONTROL**

- A. Provide in accordance with Division 01 General Requirements. Comply with applicable reference standards listed in Article 1.03.
- B. Manufacturer Field Services
  1. Furnish the services of a qualified manufacturer's field representative prior to commencement of application to provide instruction, demonstrate proper application and inspection procedures, and to inspect the finish of the prepared surfaces prior to application.

**3.05 CLEANING**

- A. Leave finished Work and Work area in a neat, clean condition without evidence of spillovers on adjacent areas.

**3.06 CLOSEOUT ACTIVITIES**

- A. Provide in accordance with Division 01 General Requirements.

**END OF SECTION**

## SECTION 26 05 00

### COMMON WORK RESULTS FOR ELECTRICAL

#### PART 1 – GENERAL

##### 1.01 SUMMARY

A. Section Includes

1. Provide labor, tools, equipment, and materials necessary to furnish and install electrical work as specified and in accordance with the Drawings and applicable reference standards listed in Article 1.03.
2. In general, electrical Work shall include but not be limited to the following.
  - a. Motor wiring, safety disconnects, and motor starters unless integral with equipment
  - b. Power distribution equipment
  - c. Power outlets and equipment connections
  - d. Wiring devices
  - e. Motor controls
  - f. Control wiring
  - g. Support material and hardware for raceway and electrical equipment
  - h. Branch circuit wiring
  - i. Installation, termination & labeling of all cable and signal wiring for instrumentation and process control equipment.
  - j. Start up, acceptance testing test reports and instruction of systems operation to the Owner

##### 1.02 PRICE AND PAYMENT PROCEDURES

- A. Measurement and payment requirements: per Division 01 General Requirements.

##### 1.03 REFERENCES

- A. Reference Standards

1. Electrical equipment, materials, installation and workmanship shall comply with all state and local building codes, safety and fire law Regulations at the location of the Work and shall conform the applicable codes and standards of the organizations listed:
    - a. American National Standards Institute, Inc. (ANSI)
    - b. Association of Edison Illuminating Companies (AEIC)
    - c. Institute of Electrical and Electronics Engineers (IEEE C2)
    - d. Insulated Power Cable Engineers Association (IPCEA)
    - e. National Electrical Code (NEC)
      - 1) Massachusetts Electrical Code (MEC)
    - f. National Electrical Manufacturers Association (NEMA)
    - g. National Fire Protection Association (NFPA)
    - h. Occupational Safety Health Act (OSHA)
    - i. Underwriters' Laboratories (UL)
  2. Where the Contract requires the Work or any part of the same, to be above the standards required by applicable Laws, ordinances, rules and Regulations and other statutory provisions pertaining to the Work, such Work shall be performed and completed as specified.
  3. Should any changes in the Specifications and Drawings be necessary to conform to the requirements of any of the above mentioned codes or standards, notify the Engineer.
- B. Drawings required by Governing Authorities: Prepare any detailed diagrams or Drawings which may be required by the governing authorities.
- C. Permits, Certificates, Inspections, Fees and Utility Costs
1. Obtain and make payments for all permits, licenses, and certificates that are required for the associated Work.
  2. Obtain certificates of approval from the responsible agencies concerned with the Work.
  3. Arrange for timely inspections required for Work under this section.

#### **1.04 ADMINISTRATIVE REQUIREMENTS**

- A. Coordination, sequencing, and scheduling: per Division 01 General Requirements.
- B. Coordinate electrical work with the Work of other trades to prevent interferences and to prevent impedance of construction progress.
- C. Coordinate with local utility companies and perform installation of their services in accordance with utility company requirements.
- D. Where lighting fixtures and other electrical items are shown in conflict with locations of structural members and mechanical or other equipment, furnish and install all required supports and wiring to clear the encroachment for a complete installation.
- E. Any Work installed contrary to or without acceptance by the Engineer shall be subject to change as directed by the Engineer at no additional cost to Owner.

#### **1.05 SUBMITTALS**

- A. Submit in accordance with Division 01 General Requirements.
- B. Furnish manufacturer's product data, test reports, and materials certifications as required.
- C. Shop Drawings to identify the specific equipment and material being supplied; the quantity being supplied; and all accessories, dimensions, descriptions, mounting and connection details, wiring diagrams, elementary control diagrams, equipment interface diagrams and any other information necessary to determine compliance with the Drawings and Specifications. Fabrication and installation shall be in accordance with the approved Shop Drawings.
- D. As-built copies of all Shop Drawings.
- E. Submit copies of reports, permits, and easements necessary for installation, use, and operation.
- F. Submit copies of reports of tests, inspections, and meter readings as specified.
- G. Closeout and maintenance material submittals: per Division 01 General Requirements.

#### **1.06 QUALITY ASSURANCE**

- A. Provide in accordance with Division 01 General Requirements.

## **1.07 DELIVERY, STORAGE, AND HANDLING**

- A. Provide in accordance with Division 01 General Requirements.

## **1.08 SITE CONDITIONS**

- A. Existing Conditions: per Division 01 General Requirements.

## **1.09 WARRANTY**

- A. Special Warranty/Extended Correction Period
- B. Compile and assemble the warranties specified in Division 26 into a separate set of vinyl covered three ring binders, tabulated and indexed for easy reference.
- C. Provide complete warranty information for each item. Information to include:
  - 1. Product or equipment list
  - 2. Date of beginning of warranty or bond
  - 3. Duration of warranty or bond
  - 4. Names, addresses, and telephone numbers and procedures for filing a claim and obtaining warranty services

## **1.10 DRAWINGS**

- A. The Specifications supplement the Drawings and provide information pertaining to the methods and materials to be used in the execution of the Work. When a discrepancy occurs contact the Engineer to resolve.
- B. All electrical equipment such as junction and pull boxes, panelboards, switches, controls and such other apparatus as may require maintenance and operation from time to time shall be made easily accessible and properly labeled.
- C. The Contractor shall examine existing documentation, and verify and properly coordinate the placement of outlets. Contractor shall also check all Drawings including mechanical Drawings and Shop Drawings for apparatus for which he must rough-in and to which he must connect.

## **1.11 RECORD DRAWINGS**

- A. Maintain a complete and separate set of prints of Drawings and Specifications at job Site for duration of the Project. Record Work completed and all changes from original Contract. Drawings shall clearly and accurately include Work installed as a modification or as an addition to the original design.

- B. At completion of Work and prior to final request for payment, submit a complete set of reproducible Record Drawings showing all systems as actually installed.

## 1.12 JOB CONDITIONS

### A. Existing Conditions

1. Existing Utilities: Locate existing underground utilities in excavation areas. If utilities are indicated to remain, support and protect services during excavation operations.
2. Prior to all Work of this section, carefully inspect the installed Work of all other trades and verify that all such Work is complete to the point where this installation may properly commence.
3. Verify that the electrical installation may be made in complete accordance with all pertinent codes and Regulations and the original design.

### B. Coordination:

1. Coordinate the installation of electrical items with the schedules for Work of other trades to prevent unnecessary delays in the total Work.
2. Coordinate with all local utility companies and make all installations for their services in accordance with all utility company requirements.
3. Any changes shall be done at the Contractor's expense.
4. Where lighting fixtures and other electrical items are shown in conflict with locations of structural members and mechanical or other equipment, furnish and install all required supports and wiring to clear the encroachment for a complete installation.
5. Any Work installed contrary to or without acceptance by the Engineer shall be subject to change as directed by the Engineer, and no extra compensation will be allowed to the Contractor for making these changes.

### C. Accuracy of Data:

1. The Drawings are diagrammatic and functional only, and are not intended to show exact circuit layouts, number of fittings, components and place in satisfactory operational power, lighting, and other electrical systems shown. Install additional circuits, components and material wherever needed to conform to the specific requirements of the equipment whether or not indicated or specified.
2. Information and components called for in the Specification but not shown on Plans or vice versa shall apply and shall be provided as though required expressly by both.

3. The locations of equipment, fixtures, outlets and similar devices shown on the Drawings are approximate only. Field measurements shall take precedence over scaled dimensions from Drawings. Exact locations shall be as accepted by Engineer during construction. Obtain in the field all information relevant to the placing of electrical work and, in case of any interference with other Work, proceed as directed by the Engineer and furnish all labor and materials necessary to complete the Work in an acceptable manner.
4. The Drawings and the Specifications are intended to comply with all pertinent codes, Regulations and standards. In the event of discrepancy, the Contractor shall immediately notify the Engineer in writing of said discrepancies and apply for an interpretation and, unless an interpretation is offered in writing by the Engineer prior to the execution of the Contract, the applicable rules and Regulations shall be complied with as a part of the Contract.
5. In case of difference between building codes, Specifications, state Laws, industry standards and the Contract Documents, the most stringent shall govern. Should the Contractor perform any Work that does not comply with the requirements of the applicable building codes, state Laws, and industry standards, he shall bear all cost arising in correcting these deficiencies.
6. Verify size and ratings of motors and other electrically operated devices supplied by others.
7. Check with Engineer before installation of Work for outlets not specified as to location or for Work that interferes with other trades.

### **1.13 PRODUCT DELIVERY, STORAGE, AND HANDLING**

- A. Use all means necessary to protect electrical system materials before, during and after installation and to protect the installed Work and materials of all other trades.
- B. In the event of damage, immediately make all repairs and replacements necessary to the acceptance of the Engineer and at no additional cost to the Owner. If any apparatus has been subject to possible injury by water, it shall be thoroughly dried out and put through such special tests as directed by the Engineer, at the cost and expense of the Contractor, or shall be replaced by the Contractor at his own expense.
- C. Protect the Work of other trades. Restore any damage caused to other trades to the condition existing prior to damage at no additional cost to the Owner.
- D. Investigate each space in the building through which equipment must pass to reach its final location. If necessary, the manufacture shall be required to ship his

material in sections sized to permit passing through such restricted areas in the building.

#### **1.14 WORK PERFORMANCE**

- A. Electrical work shall be accomplished with all affected circuits or equipment de-energized. When an electrical outage cannot be accomplished in this manner for the required Work, the following requirements are mandatory:
  - 1. Electricians must use full protective equipment (i.e., certified and tested insulating material to cover exposed energized electrical components, certified and tested insulated tools, etc.) while working on energized systems in accordance with NFPA 70E.
  - 2. Electricians must wear personal protective equipment while working on energized systems in accordance with NFPA 70E.
  - 3. Before initiating any Work, a job specific Work plan must be developed by the Contractor and the Owner. The Work plan must include procedures to be used on and near the live electrical equipment, barriers to be installed, and safety equipment to be used and exit pathways.
  - 4. Work on energized circuits or equipment cannot begin until prior written approval is obtained from the Owner.

#### **1.15 DEFINITIONS**

- A. As used in this Specification, “provide” means “furnish and install”, “furnish” means “to purchase and deliver to the Project Site complete with every necessary appurtenance and support and to store in a secure area in accordance with manufacturer’s instructions”, and “install” means “to unload at the delivery point at the Site or retrieve from storage, move to point of installation and perform every operation necessary to establish secure mounting and correct operation at the proper location in the Project”.
- B. Finished Areas: In general, areas with carpet or tile floors, lay-in or fixed ceiling tile, special architectural ceiling treatment, or tiled, plastered, or paneled walls shall be considered finished areas.
- C. Interior: For the purposes of this Specification, interior is any area within the boundaries of the foundation of any building within the superstructure or other structures not classified as a building.

#### **1.16 POSTED OPERATING INSTRUCTIONS:**

- A. Provide for each system and principal item of equipment as specified in the technical sections for use by operation and maintenance personnel. The operating instructions shall include the following:

1. Wiring diagrams, control diagrams, and control sequence for each principal system and item of equipment.
  2. Start up, proper adjustment, operating, lubrication, and shutdown procedures.
  3. Safety precautions.
  4. The procedure in the event of equipment failure.
  5. Other items of instruction as recommended by the manufacturer of each system or item of equipment.
- B. Print or engrave operating instructions and frame under glass or in approved laminated plastic. Post instructions where directed. For operating instructions exposed to the weather, provide weather-resistant materials or weatherproof enclosures. Operating instructions shall not fade when exposed to sunlight and shall be secured to prevent easy removal or peeling.

#### **1.17 MANUFACTURER'S NAMEPLATE**

- A. Each item of equipment shall have a nameplate bearing the manufacturer's name, address, model number, and serial number securely affixed in a conspicuous place; the nameplate of the distributing agent will not be acceptable.

#### **1.18 FIELD FABRICATED NAMEPLATES**

- A. Provide laminated plastic nameplates for each equipment enclosure, relay, switch, and device; as specified in the technical sections or as indicated on the Drawings. Each nameplate inscription shall identify the name of the equipment, function and, when applicable, the position. Nameplates shall be melamine plastic, 0.125 inch thick, black with white letters. Surface shall be matte finish. Corners shall be square. Accurately align lettering and engrave into the core. Minimum size of nameplates shall be one by 2.5 inches. Lettering shall be a minimum of 0.25 inch high normal block style. All electrical equipment shall be labeled with the following:
1. Panel Name
  2. Fed from "Panel Name" & "CKT #"
  3. Amps
  4. Volts
  5. Phase

### **1.19 ARC FLASH LABEL**

- A. Provide arc flash labels for all electrical equipment with operating voltages greater than 50 volt per NEC 110.16.

### **1.20 WARNING SIGNS**

- A. Exterior warning and caution signs shall be weather resistant, nonfading, preprinted cellulose acetate butyrate signs with 20-gauge, galvanized steel backing, with colors, legend, and size appropriate to the location.
- B. Interior warning and caution signs shall be aluminum signs with preprinted baked enamel finish and punched for fasteners. Colors, legend, and size appropriate to location.

### **1.21 WIRE AND CABLE MARKERS**

- A. Underground line marking tape shall be permanent, bright colored, continuous printed, metal backed, plastic tape compounded for direct burial service not less than 6 inches wide. Printed legend indicative of general type of underground line below.
- B. Wire labels for wires smaller than No. 4. shall be vinyl or vinyl cloth, self-adhesive, wraparound, wire markers with preprinted numbers and letters. Wire sizes No. 4 and larger and multi conductor cables shall be marked with one-piece, nylon locking marker ties equal to Panduit PLM Series.

## **PART 2 – PRODUCTS**

### **2.01 MATERIALS**

- A. Materials and equipment shall be listed by UL unless it can be demonstrated that no UL standards exist for a specific item or class of equipment.
- B. All other materials, not specifically described but required for a complete and operable electrical installation, shall be new, first quality of their respective kinds, Specification grade or better, and as selected by the Contractor subject to the acceptance by the Engineer.
- C. All materials and equipment furnished and installed on this Project shall meet the most stringent efficiency standards of the local utility to qualify for the maximum rebate.

### **2.02 MATERIAL AND CONSTRUCTION REQUIREMENTS**

- A. Unless otherwise shown or specified, all enclosures, motors, wiring and other materials and all construction methods shall conform to the following:

1. Indoor, Above Ground, Dry Areas - NEMA 12, General Purpose, with gasketing for applications where atmospheric conditions are normal. Enclosures shall be sheet steel, treated to resist corrosion, prime painted and finished with a gray baked-on enamel. Control stations shall have NEMA 13, oil tight and dust-tight enclosures.
2. Outdoors, Moist Areas and Indoor Below Grade Areas - NEMA 4, watertight. Enclosures shall be cast aluminum or stainless steel. Where indicated on electrical Plans provide NEMA 4X enclosures of stainless steel or reinforced non-metallic (Krydon) construction. All installations shall utilize only stainless steel fasteners/hardware.
3. Indoor-Outdoor, Subject to Submersion in Liquid - NEMA 6, submersible, liquid tight construction. Enclosures shall be cast aluminum.
4. Hazardous Areas - NEMA 7 & 9, explosion-proof construction for Class 1, Division 1, Group D areas. Enclosures shall be cast aluminum.
5. Corrosive Atmospheres - All Work located in corrosive atmospheres, such as atmospheres in the filter area and the chemical feed pump areas shall be of such construction that the corrosive agent cannot enter into and damage the electrical work. All materials in these areas shall be non-corrodible or finished with an inert coating. Stainless steel, or reinforced PVC electrical enclosures and PVC coated rigid conduit and fittings are required. In addition, provide gas tight seals in all conduits passing from or into corrosive areas (similar to Crouse Hinds Type EYS), to minimize migration of corrosive fumes to other building areas.

## 2.03 INTERCHANGEABILITY

- A. In all design and purchasing, interchangeability of items of equipment, subassemblies, parts, motors, starters, relays and other items is essential. All similar items shall be of the same manufacturer, type, model and dimensions.
- B. For ease of maintenance and parts replacement, to the maximum extent possible, use equipment of a single manufacturer.
- C. The Engineer reserves the right to reject any submittal which contains equipment from various manufacturers if suitable materials can be secured from fewer manufacturers and to require that source of materials be unified to the maximum extent possible.

## 2.04 SOURCE QUALITY CONTROL

- A. Provide in accordance with Division 01 General Requirements.

## **PART 3 – EXECUTION**

### **3.01 COORDINATION**

- A. Prior to all Work of this section, carefully inspect the installed Work of all other trades and verify that all such Work is complete to the point where this installation may properly commence.
- B. Field verify all locations and dimensions to ensure that the equipment will be properly located, readily accessible, and installed in accordance with all pertinent codes and Regulations, the Contract Documents, and the referenced standards.
- C. The Work shall be carefully laid out in advance, and where cutting, drilling, etc., of floors, walls, ceilings, or other surfaces is necessary for the proper installation, this Work shall be carefully done, and any damage to building, piping, or equipment shall be repaired by skilled mechanics of the trades involved at no additional cost to the Owner.
- D. In the event any discrepancies are discovered, immediately notify the Engineer in writing. Do not proceed with installation in areas of discrepancy until all such discrepancies have been fully resolved.

### **3.02 INSTALLATION**

- A. Install all equipment and fixtures in complete accordance with the manufacturer's recommendations and all pertinent codes and Regulations.
- B. Thoroughly inspect all items of equipment and any items dented, scratched, or otherwise damaged in any manner shall be replaced or repaired and painted to match original finish. All items so repaired and refinished shall be brought to the attention of the Engineer for inspection and acceptance.
- C. Coordinate the installation of required supporting devices and sleeves to be set in poured-in-place concrete or supported from or on other structural components, as they are constructed.
- D. Sequence, coordinate, and integrate installations of electrical materials and equipment for efficient flow of the Work. Give particular attention to large equipment requiring positioning prior to closing in the building and equipment which must be placed in service before further construction can take place.
- E. Where mounting heights are not detailed or dimensioned, install systems, materials, and equipment to provide the maximum headroom possible.
- F. The final routing of raceways shall be determined by structural conditions, interferences with other trades and by terminal locations on apparatus. The Engineer reserves the right of a reasonable amount of shifting at no extra cost up until time of roughing in the Work.

- G. Where circuits are shown as “home-runs” all necessary fittings and boxes shall be provided for a complete raceway installation.
- H. In general, wiring and raceway systems for security alarm, fire alarm, telephone and intercommunications systems are not indicated on the Drawings but shall be furnished and installed under this section.
- I. Each lighting and each receptacle circuit shall have its own neutral, dedicated to that circuit. A common neutral for more than one signal phase circuit is not allowed.
- J. Surface mounted panel boxed, junction boxes, conduits, etc., shall be supported by spacers to provide a clearance between wall and equipment.
- K. Upon completion of all installation, lamping, and testing, thoroughly inspect all exposed portions of the electrical installation and completely remove all exposed labels, soils, markings and foreign material.

### **3.03 MARKING AND LABELING**

- A. All panelboards, indoor transformers, cabinets, control panels and other specified equipment shall be labeled with engraved laminated plastic plates with engraved letters. Punch tapes with mastic backings are not acceptable.
- B. For all interior and exterior wet and corrosive locations, wire and cable markings shall be covered with clear heat shrink tubing.
- C. All starters, disconnect switches and other specified equipment shall be marked with engraved laminated plastic plates and engraved letters. Where individual switches are circuit breakers in power or distribution panel boards do not have cardholders, they shall be marked with ½” high labels.
- D. All empty conduits shall have labels tied to the pull string at each end of each empty conduit, marked as to identification of each end. Junction boxes with circuits provided for future use shall be labeled with appropriate circuit designation.
- E. All panelboards directories shall be filled out with typewritten identification of each circuit.

### **3.04 WIRE AND CABLE MARKERS**

- A. Tag control circuit conductors at both ends and at junction box splices using wire and cable markers with identification numbers as designated on equipment wiring diagrams. Provide typed listing to identify conductors by number and use.
- B. Identify spare conductors, individually, at both ends and at junction box splices with number between 1 and 999. Do not duplicate numbers.

- C. Identify wire numbers on terminal block marking strips.
- D. Provide permanent plastic name tag indicating load for each feeder for all junction boxes, handholes and manholes. Label all process motor wires to yard equipment in handholes and manholes.

### **3.05 FIELD QUALITY CONTROL**

- A. Provide in accordance with Division 01 General Requirements.
- B. Provide the services of an independent Testing Agency to perform the specified tests outlined in their respective specification sections.
- C. Provide necessary material, equipment, labor and technical supervision to perform and complete the Electrical Acceptance Tests as required.
- D. Acceptance tests as specified are defined as those tests and inspections required to determine that the equipment involved is acceptable as delivered to the job Site, that the equipment may be energized for final operational tests and is in accordance with the Specifications.
- E. Final acceptance of the equipment and/or workmanship will depend upon performance characteristics as determined by the subject tests, in addition to complete operation tests, on all electrical equipment to show that it will perform the functions for which it was designed.
- F. If the test and inspection data submitted should indicate deficiencies in the operation of the electrical apparatus or in the manufacturer thereof, the Contractor shall promptly implement the necessary adjustments, corrections, modifications and/or replacements necessary to be made to meet the specified requirements.
- G. Upon completion of the remedial Work, the Testing Agency shall repeat all of the tests on components previously found deficient on the first test or any additional test if they be required. It shall be the responsibility and obligation of the Contractor to have all remedial Work accomplished as may be required by second and/or additional tests.

### **3.06 CLEANING**

- A. When Work is complete and has been tested and accepted by Owner, clean all light fixtures, equipment, and exposed surfaces that have been directly affected by this Work. Keep the premises in a neat and orderly condition and at the completion of the Work properly clean up and remove any excess materials from Site.

### **3.07 CLOSEOUT ACTIVITIES**

- A. Provide in accordance with Division 01 General Requirements.

**END OF SECTION**

## SECTION 26 05 19

### LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

#### PART 1 – GENERAL

##### 1.01 SUMMARY

- A. Section Includes
  - 1. Provide low-voltage electrical power conductors and cables in accordance with this Section and applicable reference standards listed in Article 1.03.
  - 2. This section includes wires, cables, and connectors for power, lighting, signal, control, and related systems rated 600 volts and less.
- B. Related Requirements
  - 1. Section 26 05 00 – Common Work Results for Electrical
  - 2. Section 26 05 23 – Control-Voltage Electrical Power Cables
  - 3. Section 26 05 26 – Grounding and Bonding for Electrical Systems

##### 1.02 PRICE AND PAYMENT PROCEDURES

- A. Measurement and payment requirements: per Division 01 General Requirements.

##### 1.03 REFERENCES

- A. Reference Standards
  - 1. National Fire Protection Association (NFPA)
    - a. NFPA 70 National Electrical Code
  - 2. Underwriters Laboratories (UL)
    - a. UL 44 Standard for Thermoset-Insulated Wire and Cable
    - b. UL 83 Thermoplastic Insulated Wires and Cables
    - c. UL 486A Wire Connectors and Soldering Lugs for Use with Copper Conductors
    - d. UL 854 Service Entrance Cable
  - 3. National Electrical Manufacturers Association (NEMA)

- a. WC 70-21 Construction Requirements
- 4. Institute of Electrical and Electronic Engineers (IEEE)
  - a. Standard 82-2002 Test Procedure for Impulse Voltage Tests on Insulated Conductors

#### **1.04 ADMINISTRATIVE REQUIREMENTS**

- A. Coordination, sequencing, and scheduling: per Division 01 General Requirements.

#### **1.05 SUBMITTALS**

- A. Submit in accordance with Division 01 General Requirements.
- B. Product data
  - 1. Product data for electrical wires, cables, and connectors
  - 2. Product data for Megger insulation testing instrument
  - 3. Report sheets for Megger testing
- C. Manufacturer Reports
  - 1. Furnish manufacturer's product data, test reports, and materials certifications as required
- D. Megger Test Results
- E. Closeout and maintenance material submittals: per Division 01 General Requirements.

#### **1.06 QUALITY ASSURANCE**

- A. Provide in accordance with Division 01 General Requirements.

#### **1.07 DELIVERY, STORAGE, AND HANDLING**

- A. Provide in accordance with Division 01 General Requirements.
- B. Deliver wire and cable properly packaged in factory fabricated type containers, or wound on NEMA specified type wire and cable reels.
- C. Store wire and cable in clean dry space in original containers. Protect products from weather, damaging fumes, construction debris, and traffic.

## **1.08 SITE CONDITIONS**

- A. Existing conditions: per Division 01 General Requirements.

## **PART 2 – PRODUCTS**

### **2.01 MANUFACTURERS**

- A. American Insulated Wire Corp.
- B. General Cable.
- C. The Okonite Co.
- D. Southwire Company
- E. Or approved equal

### **2.02 MATERIALS**

- A. General
  - 1. Provide factory-fabricated wires of sizes, ampacity ratings, and materials for applications and services indicated. Where not indicated, provide proper wire selection as determined by Installer to comply with Project's installation requirements, NEC and NEMA standards.
  - 2. Provide color-coding for phase identification as specified.
  - 3. Provide factory applied nylon or polyvinyl chloride (PVC) external jackets on wires and cables for pulls in raceways over 100 feet in length, for pulls in raceways with more than three equivalent 90 degree bends, for pulls in conduits underground or under slabs on grade and where indicated.
- B. Service & Distribution Wiring
  - 1. Conductor Material: copper
  - 2. Insulation Voltage Rating: 600 volts
  - 3. Insulation: Type XHHW-2, rated 90 degrees C.
  - 4. Use XHHW for #4 and larger and THHN/THWN or XHHW for #6 and smaller
  - 5. [Where service and distribution cables are to be installed in cable trays, cables shall be rated for use in cable tray as follows:

- a. Insulation Voltage Rating: 600 volts
- b. Insulation: Type TC-ER Power Cables, rated 90 degrees C
- c. Three Conductor Copper, PVC with nylon insulation, THHN Polyvinyl Chloride Jacket with (1) bare CU Ground, Silicone Free. Provide XHHW-2 insulation for #4 and larger.
- d. Suitable for use in wet and dry areas, conduits, ducts, troughs, cable trays, direct burial, aerial supported by messenger.
- e. Capable of operating continuously at the conductor temperature not in excess of 75C in wet locations and 90C in dry locations.
- f. Suitable for use in Class I, II, and III, Division 2 hazardous locations per NEC Article 501 and 502. ]

C. Building Wiring

- 1. Conductor Material: copper
- 2. Insulation Voltage Rating: 600 volts
- 3. Insulation: Type THHN/THWN-2, rated 90 degrees C
- 4. Stranding: All 600V cable shall be stranded, except solid cable may be used for #10AWG and smaller for lighting and receptacle circuits.
- 5. Minimum branch circuit: 12 AWG
- 6. Minimum 10 AWG for 120-volt circuits more than 100 feet long
- 7. Minimum 10 AWG for 277-volt circuits more than 230 feet long
- 8. [Where building wiring is installed in cable trays, cables shall be rated for use in cable tray as follows:
  - a. Insulation Voltage Rating: 600 volts
  - b. Insulation: Type TC-ER Power Cables, rated 90 degrees C
  - c. Two or Three Copper conductors as required, PVC with nylon insulation, THHN/THWN Polyvinyl Chloride Jacket with (1) Green Insulated Ground wire.
  - d. Suitable for use in wet and dry areas, conduits, ducts, troughs, cable trays, direct burial, aerial supported by messenger.

- e. Capable of operating continuously at the conductor temperature not in excess of 75C in wet locations and 90C in dry locations.
  - f. Suitable for use in Class I, II, and III, Division 2 hazardous locations per NEC Article 501 and 502. ]
9. MC Type Armored Cable shall be used only in locations that are completely concealed for interior dry locations, or in accessible dry interior locations (such as above acoustical ceilings), unless specifically indicated otherwise. Where approved by code and local authorities, metal clad cable, type MC may be used for wiring of branch circuits for lighting switches, receptacles, etc. Cable shall have full size ground wires.

D. Control Wiring

- 1. Control wiring for digital/discrete signal wiring, shall be 600V, minimum 14 AWG, THHN/THWN-2, rated 90 degrees C, copper stranded, unless specifically indicated otherwise. Solid copper cable is not acceptable.
- 2. [Where control wiring is installed in cable trays, cables shall be rated for use in cable tray as follows:
  - a. Insulation Voltage Rating: 600 volts
  - b. Insulation: Type TC-ER Control Cables, rated 90 degrees C
  - c. Copper conductors with THHN/THWN PVC Jacket with (1) Insulated Green CU Ground. Provide with number of control conductors as required for the application.
  - d. Suitable for use in wet and dry areas, conduits, ducts, troughs, cable trays, direct burial, aerial supported by messenger.
  - e. Capable of operating continuously at the conductor temperature not in excess of 75C in wet locations and 90C in dry locations.
  - f. Suitable for use in Class I, II, and III, Division 2 hazardous locations per NEC Article 501 and 502.]

E. Variable Frequency Drive (VFD) Cable

- 1. VFD load-side power cable shall be shielded type specifically listed for use with Variable Frequency Drives.
- 2. VFD cable shall be UL listed with 600V black XLPE insulation.
- 3. Cables: stranded type with number and sizes of conductors indicated on Drawings.

4. VFD cable for cable sizes #2 and smaller: provided with 3 stranded tinned-copper circuit conductors, 1 full-sized insulated ground, overall duofoil shield plus 85 percent tinned-copper braid and full-sized tinned copper drain wire.
5. Cables sizes larger than #2 shall be provided with 3 stranded circuit conductors, 3 symmetrical bare copper grounds and 2 100 percent spiral copper tape shields.
6. Cable shall be equal to Belden Series 295XX, or Engineer approved equal.

F. Connectors

1. UL-listed, factory-fabricated wiring connectors of size, ampacity rating, material, type, and class for application and service indicated.
2. For wire sizes up to #6 AWG, use compression type. For wire sizes #250kcmil and larger, use connectors with at least two cable clamping elements or compression indents and provision for at least 2 bolts for joining to apparatus terminal.
3. Alarm, instrumentation and control wire shall be terminated using nylon insulated tin-plated copper ferrules, or nylon insulated fork type tin-plated copper compression terminals, as required for termination of cable at terminal blocks.

G. Splices

1. Splices for No. 10 and smaller shall be 600-volt pressure type insulated connector of wire-nut type, or equal; soldered and crimped type not allowed. Ideal type wire nut Buchanan type B-Cap and Minnesota Mining (3M) type Scotchlok.
2. Splices for No. 8 AWG through #1 AWG shall be solderless lugs or solderless connectors of lock-tite or similar type properly taped with plastic insulating tape, Minnesota Mining Co. #33, or equal, then two half-lap servings of friction tape, Manson, or equal.
3. For wire sizes #1/0 AWG and larger, provide circumferential compression connectors that meet the requirements in UL 486A.
4. Provide lugs and splices made from electro-tin-plated seamless copper tubing and marked with cable accommodation, die codes and crimp locations.
5. Splices shall be taped and covered with materials recommended by the cable manufacturers, to provide insulation equal to that on the conductors.

6. For wet locations splices shall be waterproofed. Compression-type splices 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 conductor. Spring connector splices shall be waterproofed by a sealant-filler with an approved waterproofed sealer.

## **2.03 SOURCE QUALITY CONTROL**

- A. Provide in accordance with Division 01 General Requirements.

## **PART 3 – EXECUTION**

### **3.01 WIRE AND CABLE INSTALLATION**

- A. Install wire and cables in conduit of size and type indicated on Drawings and Specifications.
- B. Install electrical cables, wires, and connectors in compliance with NEC.
- C. Pull conductors simultaneously where more than one is being installed in same raceway. Use UL listed pulling compound or lubricant, where necessary.
- D. Use pulling means including, fish tape, cable, rope, and basket weave wire/cable grips, which will not damage cables or raceways. Do not use rope hitches for pulling attachment to wire or cable.
- E. Conceal cable in finished spaces.
- F. Install exposed cable parallel and perpendicular to surfaces or exposed structural members, and follow surface contours, where possible.
- G. Size conductors so voltage drop does not exceed 3 percent for branch circuits or 5 percent for feeder/branch circuit combination.
- H. Provide adequate length of conductors within electrical enclosures and train the conductors to terminal points with no excess. Bundle multiple conductors, with conductors larger than 10 AWG cabled in individual circuits. Make terminations so there is no bare conductor at the terminal.
- I. Provide color coded feeder and branch circuit wiring at termination and splice locations. System neutrals: designated in addition to phase conductors. Equipment grounds shall be green.
- J. The number of conductors shown on Drawings is not necessarily the correct number required. As many conductors as are required in each case shall be installed. In general, grounding conductors are not scheduled.

- K. Service entrance conductors shall be installed without splices. Electrical equipment feeders shall be spliced only where shown or specifically approved. Control and metering conductors shall be installed without splices.
- L. All splices shall be made only by specific permission of the Engineer and then only in manholes or pull boxes and shall be sealed watertight with a heat-shrunk insulation.
- M. Tighten electrical connectors and terminals in accordance with manufacturer's published torque tightening values. Where manufacture's torquing requirements are not indicated, tighten connectors and terminals to comply with tightening torques specified in UL Standards 486A and 486B.
- N. All conductors and cables shall be labeled. Wire labels for wires smaller than No. 4. shall be vinyl or vinyl cloth, self-adhesive, wraparound, wire markers with preprinted numbers and letters. Wire sizes No. 4 and larger and multi conductor cables shall be marked with one-piece, nylon locking marker ties equal to Panduit PLM Series. Provide clear heat shrink tubing on all labels installed in interior and exterior wet/corrosive locations.
- O. Provide terminal blocks at control cable junctions within dedicated terminal boxes provided by the installer. Control wiring shall be run without splices between instruments, terminal boxes and panels.
- P. Metal Clad (MC) Cable Installation:
  - 1. No more than nine (9) total current-carrying conductors in multiple MC cable runs shall be bundled together into a single MC cable hanger. Wireway or ladder type tray with dual supports may also be used to support MC cable with fill as allowed by the NEC. Neutrals shall be counted as current-carrying conductors.
  - 2. MC cable shall be run parallel or perpendicular to walls. No diagonal runs shall be permitted.
  - 3. Maintain a clearance of at least 6 inches from hot water and other high temperature pipes and telecommunications conduits, and at least 12 inches from unshielded twisted-pair telecommunications cables.
  - 4. Securely support all MC cable with cable hangers, individual spring steel support clips, steel trapeze hangers, threaded rods or dedicated No. 8 AWG drop wires. Cable supports shall be fastened to concrete slabs, beams, joists or other structural members of the building. Do not support MC cable on hung ceilings or on ceiling support wires, or on HVAC ducts, piping, etc. The use of cable ties to support MC cable is prohibited.

5. Support MC cable every 3 feet and within 1 foot of every box, enclosure, fitting, or cable termination.
  6. All MC cables passing through fire-rated walls or electrical/telecommunications room walls shall be provided with a UL-listed, fire-rated penetration assembly.
- Q. In general, wiring for the following systems shall be installed in separate conduits. Do not mix categories in a single raceway.
1. 120 volt power wiring
  2. 120 volt control wiring, including, digital input and output signals
  3. 24 volt DC control wiring, including, digital input and output signals
  4. 24 volt DC analog control wiring (4-20mA)
  5. Communications wiring
  6. Special & Emergency Systems
- R. Power conductors 600 volts and below shall be color coded in accordance with the following:

| CONDUCTOR         | 120 / 208 COLOR | 480 / 277 COLOR |
|-------------------|-----------------|-----------------|
| Phase A           | Black           | Brown           |
| Phase B           | Red             | Orange          |
| Phase C           | Blue            | Yellow          |
| Neutral           | White           | White / Gray    |
| Equipment Grounds | Green           | Green           |

- A. Control wiring 600 volts and below shall be color coded in accordance with the following:

| CONDUCTOR                       | COLOR                  |
|---------------------------------|------------------------|
| Power Distribution Wires        | Black                  |
| Neutral Wire                    | White                  |
| AC Control Circuit Wires        | Red                    |
| DC Control Circuit Wires        | Blue                   |
| DC Common Wires                 | White w/ Blue Stripe   |
| Ground Wires                    | Green w/ Yellow Stripe |
| Wires that may remain energized | Orange                 |

|                                                                    |  |
|--------------------------------------------------------------------|--|
| when main disconnect serving the<br>circuit is in the OFF position |  |
|--------------------------------------------------------------------|--|

### 3.02 FIELD QUALITY CONTROL

- A. Provide in accordance with Division 01 General Requirements.
- B. Inspect wire and cable for physical damage and proper operation.
- C. Measure tightness of bolted connections and compare to torque measurements with manufactures recommended values.
- D. Test each electrical circuit after permanent cables are in place with terminators installed, but before cable or wire is connected to equipment or devices to demonstrate that each circuit is free from improper grounds and short circuits.
- E. For conductors larger than #8 AWG, perform Insulation-Resistance Test on each field installed conductor with respect to ground and adjacent conductors.
  - 1. Megger Testing to be witnessed by Engineer. Notify Engineer at least 48 hours in advance of testing.
  - 2. Measure insulation resistance with a digital Megger insulation testing instrument in accordance with manufacturer's recommendations. Test instruments are to be provided by the Contractor.
    - a. Applied potential shall be 500 volts dc for 300 volt rated cable and 1000 volts dc for 600 volt rated cable.
    - b. Take readings for 1 minute and until the reading is constant for 15 seconds.
  - 3. If any insulation resistance measures less than 50 megohms, the cable shall be considered faulty with cable failing the insulation test. In moist environments, bag the ends of the cable to prevent a faulty Megger test.
  - 4. Replace cable which fails insulation tests or fails when tested under full load conditions with new cable for the full length and retest.
  - 5. The below grade service or feeder splice shall be water immersion Megger tested in the presence of the Engineer. Each splice shall be immersed in a grounded water immersion bath for 24 continuous hours prior to and during the test. Criteria for failure shall be as described for cable above.

### 3.03 STARTUP & COMMISSIONING

- A. Provide in accordance with Division 01 General Requirements.

### **3.04 CLOSEOUT ACTIVITIES**

- A. Provide in accordance with Division 01 General Requirements.

**END OF SECTION**

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## **SECTION 26 05 23**

### **CONTROL-VOLTAGE ELECTRICAL POWER CABLES**

#### **PART 1 – GENERAL**

##### **1.01 SUMMARY**

- A. Section Includes
  - 1. Provide control voltage electrical power cables in accordance with this Section and applicable reference standards listed in Article 1.03.
- B. Related Requirements
  - 1. Section 26 05 00 – Common Work Results for Electrical.
  - 2. Section 26 05 26 – Grounding and Bonding for Electrical Systems.
  - 3. Section 26 05 33 – Raceways and Boxes for Electrical Systems.

##### **1.02 PRICE AND PAYMENT PROCEDURES**

- A. Measurement and payment requirements: per Division 01 General Requirements.

##### **1.03 REFERENCES**

- A. Reference Standards
  - 1. National Fire Protection Association (NFPA)
    - a. NFPA 70 National Electrical Code
  - 2. Underwriters Laboratories (UL)
  - 3. Institute of Electrical and Electronic Engineers (IEEE)

##### **1.04 ADMINISTRATIVE REQUIREMENTS**

- A. Coordination, sequencing, and scheduling: per Division 01 General Requirements.

##### **1.05 SUBMITTALS**

- A. Submit in accordance with Division 01 General Requirements.
- B. Shop Drawings: submit for approval manufacturer's technical information for shielded instrumentation cable proposed for use.

- C. Closeout and maintenance material submittals: per Division 01 General Requirements.

## **1.06 QUALITY ASSURANCE**

- A. Provide in accordance with Division 01 General Requirements.

## **1.07 DELIVERY, STORAGE, AND HANDLING**

- A. Provide in accordance with Division 01 General Requirements.

## **1.08 SITE CONDITIONS**

- A. Existing Conditions: per Division 01 General Requirements.

## **PART 2 – PRODUCTS**

- A. Instrumentation Cable
  - 1. The Okonite Company
  - 2. Belden Company
  - 3. Southwire Company
  - 4. Houston Wire & Cable
  - 5. Or equal
- B. Cable Terminations
  - 1. T&B Sta-Kon
  - 2. Burndy Insulug
  - 3. Or equal

## **2.02 MATERIALS**

- A. Shielded Instrument Cable (300V)
  - 1. Single shielded pair instrument cable: tinned copper, stranded PVC or polyethylene insulated conductors, 18 AWG minimum, twisted with aluminum-polyester or aluminum-polymer shield, stranded tinned copper drain wire, PVC outer jacket.
  - 2. Multi-paired shielded instrument cable: tinned copper, stranded PVC insulated conductors, 18 AWG minimum, twisted in pairs with aluminum-polyester or aluminum-polymer shield over each pair, silicone rubber

fiberglass fire barrier tape, tinned copper drain wire, aluminum-polyester or aluminum-polymer overall shield, PVC outer jacket.

3. Multi-conductor shielded instrument cable: tinned copper, stranded PVC insulated conductors, 18 AWG minimum, with overall aluminum-polyester shield with drain wire, PVC outer jacket.
4. Shielded 300V instrumentation cables shall be specifically listed for use for instrumentation and process control applications where protection from electrostatic interference is required.
5. Provide 600 volt shielded instrumentation cable where cable occupies the same enclosure and/or raceway with voltages greater than 300 volt as specified below.

B. Shielded Instrument Cable (600V)

1. Tinned copper, XLPE insulated stranded conductors, 18 AWG minimum, twisted pair with overall aluminum-polyester shield, stranded tinned copper drain wire, PVC outer jacket. Rated for 600 volts minimum and conforming to UL 1581.
2. Shielded 600V instrumentation cables shall be specifically listed for use for instrumentation and process control applications where protection from electrostatic interference is required.
3. Cables shall be UL listed as Type TC and approved for installation indoors or outdoors, aerially, in conduits, ducts, cable trays and direct burial not exceeding 600 volts. Suitable for use in NEC Class 1, Division 2 hazardous locations.
4. Provide with number of pairs as indicated or as required for the application

- C. Cable terminals: nylon insulated tin-plated copper ferrules, or nylon insulated fork type tin-plated copper compression terminals, as required for termination of cable at terminal blocks.

## 2.03 SOURCE QUALITY CONTROL

- A. Provide in accordance with Division 01 General Requirements.

## PART 3 – EXECUTION

### 3.01 INSTALLATION

- A. Install in conformance with the NEC. Install all cable complete with proper terminations at both ends.

- B. Install in conduit separate from power cables unless otherwise noted. Install shielded instrumentation and communications cable in ferrous metal, steel conduit throughout the entire run of conduit from end to end.
- C. Ground shield on shielded cables at the control panel only and isolated from ground at the field instrument or analyzer and at other locations as required. Shields and drain wires for spare circuits shall not be grounded at either end of the cable run. Terminals shall be provided for running signal leads and shield drain wires through junction boxes.
- D. Provide terminal blocks at instrument cable junctions within dedicated terminal boxes provided by the installer. Signal circuits shall be run without splices between instruments, terminal boxes and panels.
- E. Install and terminate vendor furnished cable in accordance with vendor equipment requirements and cable manufacturer's specific recommendations.
- F. All conductors and cables shall be labeled. Wire labels shall be vinyl or vinyl cloth, self-adhesive, wraparound, wire markers with preprinted numbers and letters. Provide clear heat shrink tubing on all labels installed in interior and exterior wet/corrosive locations.

### **3.02 TESTING**

- A. Test shielded instrumentation cable shields with an ohmmeter for continuity along the full length of the cable and for shield continuity to ground. In addition, test each conductor with ohmmeter to verify proper continuity.
- B. Connect shielded instrumentation cables to a calibrated 4-20-milliamp DC signal transmitter and receiver. Test at 4, 12, and 20 milliamp transmitter settings.

### **3.03 FIELD QUALITY CONTROL**

- A. Provide in accordance with Division 01 General Requirements.

### **3.04 STARTUP & COMMISSIONING**

- A. Provide in accordance with Division 01 General Requirements.

### **3.05 CLOSEOUT ACTIVITIES**

- A. Provide in accordance with Division 01 General Requirements.

## **END OF SECTION**

## **SECTION 26 05 26**

### **GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS**

#### **PART 1 – GENERAL**

##### **1.01 SUMMARY**

- A. Provide grounding and bonding for electrical systems in accordance with this Section and applicable reference standards listed in Article 1.03.
- B. Related Requirements
  - 1. Section 26 05 00 – Common Work Results for Electrical
  - 2. Section 26 05 19 – Low-Voltage Electrical Power Conductors and Cables
  - 3. Section 26 05 33 – Raceways and Boxes for Electrical Systems

##### **1.02 PRICE AND PAYMENT PROCEDURES**

- A. Measurement and payment requirements: per Division 01 General Requirements.

##### **1.03 REFERENCES**

- A. Institute of Electrical and Electronic Engineers (IEEE)
  - 1. IEEE 81 Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Grounded System (Part 1)
  - 2. IEEE 141 Recommended Practice for Electric Power Distribution for Industrial Plants
  - 3. IEEE 142 Recommended Practice for Grounding of Industrial and Commercial Power Systems
- B. National Electrical Code (NEC) Article 250.
- C. Underwriters Laboratories (UL)
  - 1. UL 467 Electrical Grounding and Bonding Equipment

##### **1.04 ADMINISTRATIVE REQUIREMENTS**

- A. Coordination, sequencing, and scheduling: per Division 01 General Requirements.

## **1.05 SUBMITTALS**

- A. Submit in accordance with Division 01 General Requirements.
- B. Product data for grounding equipment and appurtenances.
- C. Grounding Test Results.
- D. Closeout and maintenance material submittals: per Division 01 General Requirements.

## **1.06 QUALITY ASSURANCE**

- A. Provide in accordance with Division 01 General Requirements.

## **1.07 DELIVERY, STORAGE, AND HANDLING**

- A. Provide in accordance with Division 01 General Requirements.

## **1.08 SITE CONDITIONS**

- A. Existing conditions: per Division 01 General Requirements.

## **PART 2 – PRODUCTS**

### **2.01 GENERAL**

- A. Provide each electrical grounding system with assembly of materials required for complete installation including wires/cables, connectors, lugs, clamps, ground rods, bonding jumpers and accessories.
- B. Provide electrical grounding conductors for grounding connections matched to power supply wiring materials and sized according to NEC.
- C. Provide electrical connectors, lugs, clamps, bonding jumpers and accessories as recommended by the respective manufacturer for the particular application, unless other indicated.
- D. Ground rods: solid copper clad, 3/4-inch diameter by 10 feet long.
- E. Insulated conductors: green in color.
- F. Ground bus: bare annealed copper bars of rectangular cross section, 1/4-inch x 3-inch x length as required, with 98 percent conductivity, rigidly attached to structure.
- G. Bonding strap conductor/connectors: soft copper, 0.05 inch thick and 2-inches wide, except as indicated.

- H. Pressure connectors: high conductivity plated units.
- I. Bolted clamps: heavy-duty units listed for application.
- J. Exothermic welded connections: provided in kit form and selected for specific types, sizes, and combinations of conductors and other items to be connected.

## **2.02 SOURCE QUALITY CONTROL**

- A. Provide in accordance with Division 01 General Requirements.

## **PART 3 – EXECUTION**

### **3.01 GROUNDING & BONDING**

- A. Ground main service entrance ground bus or lug to neutral of incoming service, to enclosure, to building steel, to ground rods/grounding ring, to rebar in concrete footing, and to main cold water pipe. Install grounding bushings or service conduits. Use exothermic style ground connections to the ground rods and building steel.
- B. Use of conduit system for ground conductor is not allowed.
- C. Provide and install 600 volt insulated bonding conductors throughout the distribution system with connection to bonding (or grounding) terminal on each panel and panel board with connections to other equipment where specifically indicated and noted.
- D. Bonding conductors to be continuous where possible. Where splices are required, provide compression connectors of approved pattern. Insulate connectors to equivalent thickness of conductors.
- E. Provide grounding system for grounded circuit conductors of dry type transformer secondaries in accordance with NEC. Use exothermic style ground connections to building steel. Enclose grounding conductors in schedule 40 PVC conduit.
- F. Provide equipment grounding conductors in all conduits containing power, control, or instrumentation conductors on the load side of the service equipment or on the load side of a separately derived system.
- G. Comply with NEC Article 250 for sizes and quantities of equipment grounding conductors, except larger sizes specified. Use of metallic conduit systems for equipment grounding as recognized by the NEC are not permitted.
- H. Install grounding bushings on conduits at both primary and secondary entrances to transformers. Ground transformer enclosures to bushings.

- I. Install bonding jumper for flexible metal conduit unless fittings are approved for grounding or otherwise comply with NEC.
  - 1. Size jumper to match over-current device
  - 2. Green insulation
  - 3. Connect to grounding bushing at each end
- J. Ensure entire electrical system is electrically continuous and permanently and effectively grounded, including electrical equipment and motors.
- K. Locate ground rods with a minimum of two rod length from each other and at least the same distance from any other grounding electrode. Connect ground conductors to ground rods by means of exothermic welds except at test wells and as otherwise indicated. Drive rods until tops are 24 inches below finished floor or final grade except as otherwise indicated.
- L. Route grounding electrode conductors along the shortest and straightest paths possible without obstructing access or placing conductors where they may be subjected to strain, impact, or damage, except as indicated.
- M. Ensure that grounding electrode conductor connections to interior piping, structural members, and the like are accessible for periodic inspection during the life of the structure.

### **3.02 BONDING FOR OTHER TRADES**

- A. Signal raceways, water piping, heating piping and metallic air ducts shall be bonded together and to the grounding conductor with No. 8 soft drawn bare solid conductors. Connections to pipes shall be made with cast clamps of like material as the pipes to which attached, to ducting terminated in a secure manner by best practical means, bonding across any flexible or insulated connections.
- B. All bonding conductors shall be installed in a neat manner properly shaped for contour of surface involved and properly supported. At locations remote from the main service entrance panel boards, bond to the largest raceway nearby.

### **3.03 FIELD TESTING**

- A. Perform point-to-point tests to determine resistance between the main grounding system and all major electrical frames, system neutral, and derived neutral points. Perform tests using clamp-on digital ground resistance tester with 2% accuracy or better.
- B. Perform ground fault protection system functional testing for distribution equipment having ground fault protection.

- C. Perform ground continuity and functional tests:
  - 1. From main switchgear to grounding electrode and/or cold water main.
  - 2. Between each main secondary feeder switchboard ground and its termination point (distribution panels, panelboards, motor control centers, UPS systems, electric heater disconnects, chiller starters, and other such equipment) and all feeders shown on single-line diagram.
  - 3. Between each distribution panel to panelboards and between each panelboard to panelboard (excluding branch circuits).
  - 4. Test each branch circuit receptacle for proper polarity and ground using a plug-in test device.
- A. Provide the services of an independent testing agency to perform the specified tests for the following systems.
  - 1. Ground system resistance: Testing company to perform testing according to National Electrical Testing Association (NETA) standards and procedures. Testing results to be submitted on NETA forms and testing data e certified by the respective agency. Test results shall indicate recommended action for a sub-par test results. Results shall list recommended test values that should be obtained for new installation.
  - 2. Measure ground resistance without the soil being moistened by any means other than natural precipitation or natural drainage or seepage and without chemical treatment or other artificial means of reducing natural ground resistance. Perform tests by the three-point fall of potential method in accordance with Section 9.03 of IEEE 81. Simple moisture addition is not acceptable.
    - a. Ground/resistance maximum values shall be as follows.
      - 1) Equipment rated 500 kVA and less: 10 ohms.
      - 2) Equipment rated 500 kVA to 1000 Kva: 5 ohms.
      - 3) Equipment rated over 1000 kVA: 3 ohms.
      - 4) Unfenced substations and pad mounted equipment: 5 ohms.
      - 5) Fence Grounds: 10 ohms.
- D. Where ground resistances exceed specified values, and if directed, modify the grounding system to reduce resistance values.

**3.04 FIELD QUALITY CONTROL**

- A. Provide in accordance with Division 01 General Requirements.

**3.05 STARTUP & COMMISSIONING**

- A. Provide in accordance with Division 01 General Requirements.

**3.06 CLOSEOUT ACTIVITIES**

- A. Provide in accordance with Division 01 General Requirements.

**END OF SECTION**

## **SECTION 26 05 33**

### **RACEWAYS AND BOXES FOR ELECTRICAL SYSTEMS**

#### **PART 1 – GENERAL**

##### **1.01 SUMMARY**

- A. Section Includes
  - 1. Provide the labor, tools, equipment, and materials necessary to furnish and install raceways, boxes, and supporting devices in accordance with the Plans and applicable reference standards listed in Article 1.03.
- B. Types of products specified in this section include
  - 1. Conduit, Raceways & Fittings
  - 2. Supporting Devices
  - 3. Boxes and Fittings
- C. Related Requirements
  - 1. Section 26 05 00 – Common Work Results for Electrical

##### **1.02 PRICE AND PAYMENT PROCEDURES**

- A. Measurement and payment requirements: per Division 01 General Requirements.

##### **1.03 REFERENCES**

- A. Reference Standards
  - 1. National Electrical Code (NEC)
    - a. Massachusetts Electrical Code (MEC)
  - 2. National Electrical Manufacturers Association (NEMA)
  - 3. Underwriters Laboratories (UL)

##### **1.04 ADMINISTRATIVE REQUIREMENTS**

- A. Coordination, sequencing, and scheduling: per Division 01 General Requirements.

## **1.05 SUBMITTALS**

- A. Submit in accordance with Division 01 General Requirements.
- B. Furnish manufacturer's test reports, and material certifications as required.
- C. Product data for cabinets and enclosures.
- D. Shop Drawings for shop fabricated (non-stock items) floor boxes and boxes, enclosures and cabinets.
- E. Closeout and maintenance material submittals: per Division 01 General Requirements.

## **1.06 QUALITY ASSURANCE**

- A. Provide in accordance with Division 01 General Requirements.

## **1.07 DELIVERY, STORAGE, AND HANDLING**

- A. Provide in accordance with Division 01 General Requirements.

## **1.08 SITE CONDITIONS**

- A. Existing conditions: per Division 01 General Requirements.

## **PART 2 – PRODUCTS**

### **2.01 CONDUIT, RACEWAYS & FITTINGS**

- A. Provide conduit with 3/4-inch diameter minimum, except where specifically shown smaller on Drawings.
- B. Conduit, connectors, and fittings shall be approved for the installation of electrical conductors.
- C. Refer to Table 3.01A for approved conduit installation guidelines.
  - 1. Electrical Metallic Tubing (EMT)
    - a. EMT shall be rigid metallic conduit of the thin wall type in straight lengths, elbows, or bends and must conform to NEMA C80.3 and the requirements of UL 797.
    - b. Couplings and connectors shall be steel compression fittings. Where EMT enters outlet boxes, cabinets, or other enclosures, connectors must be the insulated-throat type, with a locknut. Fittings must meet the requirements of NEMA FB 1.

2. Rigid Galvanized Steel Conduit

- a. Rigid steel conduit (RGS), including couplings, elbows, bends, and nipples, shall conform to the requirements of UL 6 and NEMA C80.1 Steel fittings shall be galvanized by the hot-dip process.
- b. Fittings for rigid steel conduit shall be threaded and shall conform to NEMA FB 1.
- c. Gaskets shall be solid for fittings sized 1-1/2 inches and less. Conduit fittings with blank covers shall have gaskets except in clean, dry areas or at the lowest point of a conduit run where drainage is required.
- d. Covers shall have captive screws and be accessible after the Work has been completed.

3. Rigid Plastic Conduit

- a. PVC Schedule 40: Conduit shall be made of polyvinyl chloride compound that shall be homogeneous plastic material free from cracks, holes or foreign inclusions. Conduit shall be rated for use with 90 degree C conductors, UL Listed. Use solvent cement to join conduits as manufactured the same as the conduit manufacturer.
- b. PVC Schedule 80: Heavy wall PVC conduit that shall be made of polyvinyl chloride compound that shall be homogeneous plastic material free from cracks, holes or foreign inclusions. Conduit shall be rated for use with 90 degree C conductors, UL Listed. Use solvent cement to join conduits as manufactured the same as the conduit manufacturer.

4. Flexible Metallic Conduit

- a. Provide UL1 flexible metallic conduit.
- b. Provided liquid tight flexible metallic conduit with a protective jacket of PVC extruded over a flexible interlocked galvanized steel core to protect wiring against moisture, oil, chemicals, and corrosive fumes.
- c. Provide UL 514B fittings for flexible metallic conduit, Type I box connector, electrical, Type III coupling, electrical conduit, flexible steel, or Type IV adapter, electrical conduit.

5. Conduit Seals

- a. Provide factory fabricated watertight conduit sealing bushing assemblies suitable for sealing around conduit, or tubing passing through concrete floors and walls. Provide a cast in place water stop wall sleeve with a mechanical pipe seal between the conduit and the sleeve. Construct seals with steel sleeve, malleable iron body, neoprene sealing grommets or rings, metal pressure rings, pressure clamps, and cap screws.
- b. Provide E.Y.S. seal fittings with appropriate potting material where conduits enter or leave a Class 1, Division 1 or 2 environments or a Class 2, Division 1 or 2 environment, and chemical rooms.

## 2.02 SUPPORTING DEVICES

- A. Supports, support hardware, and fasteners shall be protected with zinc coating or with treatment of equivalent corrosion resistance using approved alternative treatment, finish, or inherent material characteristic. Products for use outdoors shall be hot dip galvanized unless material is inherently corrosion resistant.
- B. Refer to Table 2.02A for approved supporting device installation guidelines.
  1. Conduit Supports
    - a. Single run hangers: galvanized steel conduit straps or clamps, or cast metal beam clamps. Perforated straps and spring steel clips and clamps will not be permitted.
    - b. Group run hangers: minimum 12-gauge galvanized performed U-channel rack with conduit fittings; 25 percent spare capacity
    - c. Hanger rods: threaded steel, 3/8-inch diameter, or as identified on Drawings
    - d. Vertical run supports: minimum 12-gauge galvanized performed U-channel struts with conduit fittings
  2. Equipment and Lighting Supports
    - a. 12-gauge galvanized performed U-channel struts with fixture and conduit fittings, as applicable, unless indicated otherwise on Drawings.

3. Corrosive Area Supports
  - a. Clamp hangers, pipe straps, and clamp back spacers for use with PVC-coated rigid metal conduit shall have 40 mil gray PVC exterior coating.
  - b. Provide nonmetallic PVC material clamp hangers, pipe straps, etc. for use with PVC nonmetallic conduit.
  - c. Hanger rods: 20 mil gray PVC exterior coated rod with threaded ends only 3/8-inch and 1/2-inch sizes as required.
  - d. Strut support: 20 mil gray PVC exterior coating strut. Standard channel, slotted channel, and back to back channel are acceptable.
  - e. Provide stainless steel supports and accessories in lieu of PVC coated supports when indicated in Table 2.02A below.

**TABLE 2.02A – Supporting Devices**

| Location/Equipment         | Acceptable Support Type    |
|----------------------------|----------------------------|
| Electrical & Control Rooms | Galvanized Steel U-Channel |
| Utility & Mechanical Rooms | Galvanized Steel U-Channel |
| Exterior                   | Galvanized Steel U-Channel |
| WTF Basement               | Galvanized Steel U-Channel |
| WTF Finished Spaces        | Galvanized Steel U-Channel |
| WTF Chemical Room          | 304 Stainless Steel        |

## 2.03 BOXES AND FITTINGS

- A. Boxes must have sufficient volume to accommodate the number of conductors entering the box in accordance with NFPA 70 and UL 514A.
- B. In general, boxes that are exposed to weather, process areas, normally wet locations, and locations exposed in mechanical spaces shall be cast-metal. Boxes in all other finished areas shall be sheet metal. Boxes installed in corrosive areas, such as the chemical feed room, shall be nonmetallic.
- C. Refer to Table 2.03A for approved enclosure types.
  1. Sheet Metal Outlet Boxes
    - a. Sheet Metal Outlet Boxes: Standard type galvanized steel, minimum four inch square or octagon by 1-1/2 inch deep.

- b. Luminaire and Equipment Supporting boxes: Rated for weight of equipment supported; include 2 inch male fixture studs where required.
  - c. Single Wall Type: Minimum size, four inch square by 1-1/2 inch or 2-1/8 inch deep, except as noted. Provide dry wall device covers raised 3/4 inch minimum to insure flush finish mounting.
  - d. Ganged Wall Type: Minimum depth three inches except as noted, ganged as required under common plate to contain devices shown. On 277-volt circuits, ganged boxes for switches shall contain only one circuit or equip box with permanent barriers per NEC Art 404-8.
- 2. Cast Outlet Boxes
  - a. Type FS shallow and type FD deep, cast ferroalloy
  - b. Provide number of threaded hubs as required.
  - c. Use in all exterior, damp and locations exposed in mechanical spaces.
  - d. Provide gasketed cover and accessories by box manufacturer for complete weatherproofing. Provide correct box to accept weatherproof covers as specified.
- 3. Sheet Metal Pull & Junction Boxes
  - a. Sheet metal boxes shall be standard type galvanized steel and must conform to UL 50.
  - b. Box dimensions shall be minimum four inch square or octagon by 2 1/2 inch deep.
  - c. Sizes up to 12 by 12 by 6 inches: Provide screw-type or hinged covers.
  - d. Sizes greater than 12 by 12 by 6 inches: Provide hinged covers.
  - e. Boxes shall be sized to accommodate all incoming raceways.

4. Nonmetallic Outlet, Device, and Wiring Boxes
  - a. Conform to NEMA OS 2, Nonmetallic Outlet Boxes, Device Boxes, Covers, and box Supports, and UL 514C, Nonmetallic Outlet Boxes, Flush Device Boxes and Covers. Boxes shall be molded polyvinyl chloride (PVC), or fiberglass units of type, shape, size, and depth to suit location and application.
  - b. Boxes shall be equipped with threaded screw holes for device and cover plate mounting. Each box shall have a molded cover of matching material suitable for the application and location installed.

**TABLE 2.03A – Electrical Enclosure Types**

| Location/Equipment         | Acceptable Enclosure Type |
|----------------------------|---------------------------|
| Electrical & Control Rooms | NEMA 1G                   |
| Utility & Mechanical Rooms | NEMA 12                   |
| Exterior                   | NEMA 4X                   |
| WTF Basement               | NEMA 12                   |
| WTF Finished Spaces        | NEMA 1                    |
| WTF Chemical Room          | NEMA 4X                   |

## 2.04 SOURCE QUALITY CONTROL

- A. Provide in accordance with Division 01 General Requirements.

## PART 3 – EXECUTION

### 3.01 CONDUIT

- A. Uses Permitted
  1. Use liquid tight flexible metal conduit for the final 24 inches of connections to motors or control items subject to movement or vibration.
  2. Use RGS for all exterior aboveground installations unless otherwise noted.
  3. Use PVC coated rigid steel conduit, or as scheduled below, for installation in corrosive areas, and other areas as identified on the Drawings.
  4. Exposed raceways in Manufacturing Areas, Utility Rooms, Mechanical Rooms, Warehouse Areas, etc., shall be Rigid Galvanized Steel below 15 feet.
  5. Conduit and raceway runs in finished areas concealed in or behind walls, above ceilings, or exposed on walls and ceilings 15 feet or more above

finished floors and not subject to mechanical damage may be electrical metallic tubing (EMT).

6. Use Schedule 40 PVC conduit for exterior direct buried installations. Use Schedule 40 PVC conduit for exterior concrete encased installations. Use Schedule 80 PVC conduit for underground installations under driveways. The transition from underground and from concrete encasement to riser shall be PVC coated rigid steel conduit to a minimum of 12 inches above finished floor and/or finished grade elevation. All elbows shall be prefabricated Rigid Steel to prevent wire burn through. Reference Section 26 05 43 for further requirements.
7. Install conduit seals for conduit penetrations of slabs on grade and exterior walls below grade and where indicated. Tighten sleeve seal screws until sealing grommets have expanded to form watertight seal. Provide seals for interior of conduits penetrating exterior or water bearing walls, consisting of gland type sealing bushings or RTV closed cell silicone foam.
8. Refer to Table 3.01A below for approved conduit types.

**TABLE 3.01A – Conduit Types**

| <b>Location/Equipment</b>  | <b>Approved Conduit Type</b> |
|----------------------------|------------------------------|
| Electrical & Control Rooms | Electrical Metallic Tubing   |
| Utility & Mechanical Rooms | Electrical Metallic Tubing   |
| Exterior                   | Rigid Galvanized Steel       |
| WTF Basement               | Electrical Metallic Tubing   |
| WTF Finished Spaces        | Electrical Metallic Tubing   |
| WTF Chemical Room          | Schedule 80 PVC              |

- B. Power, lighting, control, emergency light and power, and special-service systems and all related components shall be installed in accordance with NFPA 70, and shall be enclosed in separate conduit or separate conduit systems as indicated on the Drawings and as specified herein.
- C. Any run of conduit between outlet and outlet, between fitting and fitting, or between outlet and fitting shall contain no more than the equivalent of three 90-degree bends, including those bends located immediately at the outlet or fitting. Field bends shall be made in accordance with the manufacturer's recommendations, which normally require use of a one-size-larger bender than would be required for uncoated conduit. Installed conduit and fittings shall be free of dirt and trash and shall not be deformed or crushed. Empty conduit shall have a pull rope stalled.
- D. Conduit shall be installed with a minimum of 3 inches of free air space separation from mechanical piping.

- E. Conduit in finished areas shall be installed concealed. Conduit passing through masonry or concrete walls shall be installed in sleeves. Conduit shall be securely clamped and supported at least every 10 feet vertically and 8 feet horizontally. Galvanized pipe straps shall be fastened to structure with bolts, screws, and anchors. Wooden masonry plugs shall not be used.
- F. Install exposed conduits, parallel or perpendicular to walls, ceilings, or structural members. Do not run through structural members. Avoid horizontal runs within partitions or sidewalls. Avoid ceiling inserts, lights, or ventilation ducts or outlets. Do not run conduits across pipe shafts or ventilation duct openings and keep conduits a minimum of 6 inches from parallel runs of flues, hot water pipes, or other sources of heat. Wherever possible, install horizontal raceway runs above water and steam piping.
- G. Do not run conduits exposed on exterior surface of buildings. Seal conduits penetrating exterior walls below grade, at grade floors, or below grade floors to prevent moisture migration. Seal conduit exterior with a mechanical pipe seal. Interior conduit seal shall be a gland type sealing bushing or RTV closed cell silicone foam. Ensure that conduits do not retain water against these seals.
- H. Raceways penetrating fire rated walls, floors, and partitions shall be sealed with a fire rated sealant.
- I. Support conduits with materials specifically made for this purpose. Do not use wire hangers. Do not attach any parts of the raceway system to ventilation ducts. Conduit supports shall be attached to the building. Support conduits on each side of bends and on a spacing not to exceed the following: 6 feet for conduits smaller than 1 1/4-inches and 8 feet for conduits 1 1/4-inches and larger. Support riser conduits at each floor level with clamp hangers. Securely anchor underground conduits to prevent movement during placement of concrete or backfill. Use precast separators and heavy gauge wire ties or other approved fasteners.
- J. Provide E.Y.S. seal fittings with appropriate potting material where conduits enter or leave a Class 1, Division 1 or 2 environments or a Class 2, Division 1 or 2 environment, and chemical rooms.
- K. Conduit connections to boxes and fittings shall be supported not more than 36 inches from the connection point. Conduit bends shall be supported not more than 36 inches from each change in direction. Conduit shall be installed in neat symmetrical lines parallel to the centerlines of the building construction and the building outline. Multiple runs shall be parallel and grouped whenever possible on common supports. Exposed ends of conduit without conductors shall be sealed with watertight caps or plugs.
- L. Bonding wires shall be used in flexible conduit for all circuits. Flexible conduit shall not be considered a ground conductor.

- M. Liquid tight flexible metallic conduits shall be used in wet and oily locations and to complete the connection to motor-driven equipment.
- N. Electrical connections to vibration-isolated equipment shall be made with flexible metallic conduit in a manner that will not impair the function of the equipment.
- O. A polypropylene pull rope with a tensile strength not less than 130 pounds shall be installed in empty conduit.
- P. Electrical conduit may be embedded in concrete according to the provisions of Article 6.3 of ACI 318 Building Code Requirements for Reinforced Concrete, provided the following conditions are met:
  - 1. Outside diameter of conduit shall not exceed 1/3 of concrete thickness. Maximum conduit outside diameter shall not exceed 3 inches when embedded in slab.
  - 2. Conduit shall not be placed closer than three diameters on center. Route conduit to minimize crossing of different conduit runs.
  - 3. Conduit shall not be embedded in structural concrete slabs less than four inches thick.
  - 4. A 1-1/2 inch minimum concrete cover shall be provided for conduits in structural concrete slabs.
- Q. Installation of Underground Conduit
  - 1. Minimum of 3/4 inch conduit in or under concrete slab on grade.
  - 2. Where conduits are installed in concrete slabs, on the ground, underground, or exposed to the weather, make all joints liquid tight and gas tight.
  - 3. Bury all underground conduit, except under concrete slabs placed on fill, to a depth of at least 30 inches below finished grade unless otherwise indicated on the Drawings .
  - 4. Slope ducts to drain away from buildings into manholes and/or handholes. Adjust final slopes to coordinate with existing Site utilities.
  - 5. Install on undisturbed soil where possible. Concrete encase conduits as shown on Drawings. Use pit run gravel and sand, placed 8-inch lifts and compacted for backfill.
  - 6. Reference Section 26 05 43 for further requirements.
- R. Installation of Rigid Metal Conduit

1. Ends of conduit shall be cut square, reamed and threaded, and joints shall be brought butt-to-butt in the couplings. Joints shall be mechanically tight. Conduit shall be protected against damage and the entrance of water or foreign material during construction.
2. Ninety-degree bends of conduit with a diameter larger than 1 inch shall be made with factory-made elbows. Conduit elbows larger than 2 1/2 inches shall be long radius. Field-made bends and offsets shall be made with an approved hickey or conduit-bending machine. Changes in directions of runs shall be made with symmetrical bends or cast-metal fittings.
3. At connections to sheet metal enclosures and boxes, a sufficient number of threads shall project through to permit the bushing to be drawn tight against the end of the conduit, after which the locknut shall be pulled up sufficiently tight to draw the bushing into firm electrical contact with the box. Conduit shall be fastened to sheet metal boxes and cabinets with two locknuts where required by NFPA 70 where insulating bushings are used, where bushings cannot be brought into firm contact with the box, and where indicated.
4. Conduit joints shall be made with tapered threads set firmly. Each length of conduit cut in the field shall be reamed before installation. Where conduit is threaded in the field, each threaded end shall consist of at least five full threads. Corrosion-inhibitive compound (cold galvanizing paint) shall be used on all conduit threads or any locations where the original hot galvanized surface has been compromised.
5. Conduit stubbed-up through concrete floors for connections to free-standing equipment except motor-control centers, cubicles, and other such items of equipment shall be provided with a minimum of a 12 inch riser above the floor slab is of sufficient thickness; if not, a floor box shall be provided and set flush with the finished floor. Conduits installed for future use shall be terminated with a coupling and plug set flush with the floor.

### 3.01 SUPPORTING DEVICES

- A. Install supporting devices to fasten electrical components securely and permanently in accordance with NEC requirements.
- B. Coordinate with the building structural system and with other electrical installations.
- C. Conform to manufacturer's recommendations for selection and installation of supports.
- D. Install individual and multiple (trapeze) raceway hangers and riser clamps as necessary to support raceways. Provide U-bolts, clamps, attachments, and other

hardware necessary for hanger assembly and for securing hanger rods and conduits.

- E. Support parallel runs of horizontal raceways together on trapeze type hangers.
- F. Support individual horizontal raceways by separate pipe hangers. Spring steel fasteners may be used in lieu of hangers only for 1 1/2 inch and smaller raceways serving lighting and receptacle branch circuits above suspended ceilings only. For hanger rods with spring steel fasteners, use 1/4 inch diameter or larger threaded steel. Use spring steel fasteners that are specifically designed for supporting single conduits or tubing.
- G. In vertical runs, arrange support so the load produced by the weight of the raceway and the enclosed conductors is carried entirely by the conduit supports with no weight load on raceway terminals.
- H. Support miscellaneous electrical components as required to produce the same structural safety factors as specified for raceway supports. Install metal channel racks for mounting cabinets, panelboards, disconnects, control enclosures, pull boxes, junction boxes, transformers, and other devices.
- I. Install sleeves in concrete slabs and walls and all other fire rated floors and walls for raceways and cable installations. For sleeves through fire rated wall or floor construction, apply UL listed fire-stopping sealant in gaps between sleeves and enclosed conduits and cables.

### **3.02 BOXES AND FITTINGS**

- A. Pullboxes shall be furnished and installed where necessary in the conduit system to facilitate conductor installation. Conduit runs longer than 100 feet or with more than three right angle bends shall have a pull box installed at a convenient intermediate location.
- B. Boxes and enclosures shall be securely mounted to the building structure with supporting facilities independent of the conduit entering or leaving the boxes.
- C. Bonding jumpers shall be used around concentric or eccentric knockouts.
- D. Installation of Outlet Boxes
  - 1. Use nonmetallic boxes in corrosive areas such as chemical feed area and as designated on the Plans.
  - 2. Use explosion proof boxes in Hazardous areas as identified on the Drawings.
  - 3. Use cast metal boxes in all other locations. Each box with associated covers and fittings shall have a NEMA rating for each location installed.

E. Installation of Pull and Junction Boxes

1. Use general-purpose boxes (NEMA 1) in finished areas with framed construction.
2. Use dust-tight and oil-tight boxes (NEMA 12) in other dry interior areas.
3. Use explosion proof boxes (NEMA 7) in hazardous areas as designated on the Plans.
4. Use watertight boxes (NEMA 4) for exterior and wet locations on outdoor structure where moisture is present.
5. Use corrosion resistant watertight boxes (NEMA 4X) for wet locations and corrosion filled areas, such as the chemical feed area, and as identified on the Drawings.

**3.03 FIELD QUALITY CONTROL**

- A. Provide in accordance with Division 01 General Requirements.

**3.04 STARTUP & COMMISSIONING**

- A. Provide in accordance with Division 01 General Requirements.

**3.05 CLOSEOUT ACTIVITIES**

- A. Provide in accordance with Division 01 General Requirements.

**END OF SECTION**

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## SECTION 26 08 00

### COMMISSIONING OF ELECTRICAL SYSTEMS

#### PART 1 – GENERAL

##### 1.01 SUMMARY

A. Section Includes

1. Perform Acceptance Tests for all electrical equipment furnished in accordance with this Section and applicable reference standards listed in Article 1.03.
  - a. The test requirements for equipment shall be as required by applicable standards and manufacturer's recommendations, and in accordance with this Specification. In no case will the absence of test requirements be construed as alleviation of acceptance testing.
  - b. The purpose of electrical field acceptance tests is to ensure that all electrical equipment is operational and within industry and manufacturer's tolerances and is installed in accordance with the Specifications and approved Shop Drawings.
  - c. Tests are in addition to factory tests at the Manufacturer's facility, and may not substitute for same.
  - d. Tests are in addition to all other tests specified under other Specifications and shall be coordinated by the Contractor.
  - e. Tests in general shall be conducted after the equipment installation is complete. Tests shall be complete and in order given and/or in Specifications for the particular equipment unless otherwise approved by the Engineer.
  - f. Tests are also intended to provide, ensure, or determine the following:
    - 1) Provide initial acceptance tests and recorded data that can be used as a benchmark for future routine maintenance and troubleshooting by plant personnel.
    - 2) Ensure a successful start-up with a minimum of last minute interruptions and problems.
    - 3) Determine the suitability of the equipment and systems for energization and placing into operation.

- 4) Provide assurance that each system component is not only installed satisfactorily but performs, and will continue to perform its function in the system with reasonable reliability throughout the life of the equipment.

B. Related Requirements

1. Section 26 05 00 – Common Work Results for Electrical

**1.02 PRICE AND PAYMENT PROCEDURES**

- A. Measurement and payment requirements: per Division 01 General Requirements.

**1.03 REFERENCES**

A. Reference Standards

1. American National Standards Institute (ANSI)
2. American Society for Testing and Materials (ASTM)
3. Association of Edison Illuminating Companies (AEIC)
4. Canadian Standards Association (CSA)
5. Institute of Electrical and Electronic Engineers (IEEE)
6. Insulated Cable Engineers Association (ICEA)
7. International Electrical Testing Association (NETA)
8. National Electrical Manufacturer's Association (NEMA)
9. National Fire Protection Association (NFPA)
10. Occupational Safety and Health Administration (OSHA)
11. Underwriters Laboratory (UL)

**1.04 ADMINISTRATIVE REQUIREMENTS**

- A. Coordination, sequencing, and scheduling: per Division 01 General Requirements.

**1.05 SUBMITTALS**

- A. Submit in accordance with Division 01 General Requirements.
1. Detailed test procedure including test equipment for all field acceptance testing prior to testing.

2. Submit 6 copies of test reports to the Engineer for approval.
  3. Each test report shall include as minimum the following:
    - a. Listing of equipment tested including the list of test equipment used and the test equipment's associated calibration dates
    - b. Test method and standards governing the test
    - c. Test results
    - d. Recommendations
  4. Test results shall incorporate inspection reports, instrument calibration curves, plotted test results, and all measurements and data.
  5. All inspections, tests, and calibrations are to be reported in writing. The recorded data form shall have the signatures of the persons conducting the tests and authorized witnesses. The forms shall be designed to serve as the test and inspection checklist for inspection requirements. The test and checkout data shall also include any data taken prior to the adjustments, repairs, drying out, or similar Work prior to final testing and acceptance. As-found and as-left test data shall be recorded and reported in writing.
  6. Copies of Test Data Reports shall be incorporated in each of the related Operations and Maintenance Manuals. The Data Reports shall include those items of equipment contained in the Service Manual. Reports shall be separated by a divider labeled Electrical Field Acceptance Tests. Reports shall contain data for all power conductors and controls including instrumentation conductors and devices for static and dynamic equipment in the Operations and Maintenance Manual. In addition, Operating Tests of the equipment shall be included in this section of the Operations and Maintenance Manual.
- B. Closeout and maintenance material submittals: per Division 01 General Requirements.

## 1.06 QUALITY ASSURANCE

- A. Provide in accordance with Division 01 General Requirements.
- B. Qualifications: per Division 01 General Requirements for testing and as follows.
  1. Engage the services of a recognized independent testing agency approved by the Engineer to perform acceptance tests as specified.
    - a. The testing firm shall submit proof of the certification by NETS or NICET, and proof of the qualifications for the lead, on-Site technical person when requested.

2. The testing firm shall provide all material, equipment, labor, and technical supervision to perform such tests and inspections.
3. All cost associated with the testing shall be the responsibility of the Contractor, including the expenses of retest because of defects and failure of equipment to meet Specifications.
4. Wiring and equipment which is defective, or which fails to meet Specifications, shall be replaced by the Contractor, unless specific approval for repair is given by the Engineer. The Contractor shall bear the costs for either action.
5. Open circuits, place and connect all instruments and equipment needed for the tests, remove same and restore circuits when tests are complete.
6. Coordinate activities, and cooperate with others on Project, to ensure that systems are energized when required, loads applied, and requirements of other Specification Sections are carried out on timely, coordinated basis.
7. Other Specification sections may require services of one or more manufacturer's representatives, to ensure that equipment supplied has been installed properly and adjusted to proper working order. Advise representative of all applicable tests in this Section, so that Work will be coordinated, and tests combined where feasible.
8. Notify the Engineer, in writing; at least 14 calendar days before the test are to take place. The tests shall be conducted in the presence of the Engineer or his representative and shall not be started without his permission.
9. Perform all tests as closely as possible to conditions of actual use.
10. All testing and checkout Work shall be performed with fully qualified personnel skilled in the particular tests being conducted. This is essential for obtaining and properly evaluating data while the tests are in progress and for insuring that important facts and questionable data are reported.
11. It is important that equipment warranties or guarantees not be voided by the Contractor's testing and checkout Work. The tests will normally be supplemental to and compatible with the manufacturer's installation instructions and recommendations. Where deviations are apparent, the manufacturer's review and approval shall be obtained prior to testing. Reasonable cooperation is to be extended to permit witnessing by the manufacturer's representative if so requested. Where any questionable repairs, modifications, significant adjustments, tests or checks are to be made, contact the Owner to determine if the Work should be performed by or with the manufacturer's representative.

12. Ensure that all testing and checkout Work is conducted in a safe manner. Special safety pre-cautions such as the following to be utilized where appropriate:
  - a. Occupational Safety and Health Act (OSHA)
  - b. Accident Prevention Manual for Industrial Operations, National Safety Council
  - c. Applicable state and local safety operating procedures
  - d. Owner safety procedures
  - e. National Fire Protection Association (NFPA 70E)
  - f. American National Standards for Personnel Protection
  - g. Locking procedures
  - h. Barricades
  - i. Maintenance of voice communications
  - j. Erection of warning signs
  - k. Stationing of guards and watchmen
  - l. De-energize and/or isolate equipment prior to testing. Exceptions must be thoroughly reviewed to identify safety hazards and devise adequate safeguards.
13. The sequence of all tests and checks shall be such that the equipment can be energized immediately after the completion of the applicable tests.

#### **1.07 DELIVERY, STORAGE, AND HANDLING**

- A. Provide in accordance with Division 01 General Requirements.

#### **1.08 SITE CONDITIONS**

- A. Existing conditions: per Division 01 General Requirements.

## **PART 2 – PRODUCTS**

### **2.01 MATERIALS**

#### **A. Test Equipment**

1. Provide all necessary test equipment and tools as specified and as recommended by the tested equipment manufacturer.
2. All test equipment shall be in good mechanical and electrical conditions and be calibrated per NETA ATS schedule requirements. Records which show date and results of instrument calibration or testing must be kept up-to-date and provided with the test report upon request.
3. The accuracy shall be directly traceable to the National Institute of Standards and Technology.
4. Calibrating standard shall be of higher accuracy than that of the instrument tested.
5. Test equipment shall include but not limited to and shall have operating accuracy equal to, or better than listed.
  - a. Portable multimeters shall be true RMS measuring
  - b. Multimeters shall have the following accuracy limits, or better (for 60 Hz where applicable)
    - 1) AC voltage ranges: 0.75 percent plus or minus 3 last single digits
    - 2) AC current ranges: 0.90 percent plus or minus 3 last single digits, including adapters, transducers
    - 3) DC voltage ranges: 0.25 percent plus or minus 1 last single digit
    - 4) Resistance ranges: 0.50 percent plus or minus 1 last single digit
    - 5) Frequency range: 0.10 percent plus or minus 1 last single digit
  - c. Clamp-on ammeters: AC current plus or minus 3 percent of range plus or minus 1 last single digit

- d. Dissipation/power factor field equipment
  - 1) Plus or minus 0.1 percent power factor values up to 2.0 percent
  - 2) 5 percent of the reading for power factor values above 2
- e. Low-range DC resistance equipment: 1.0 percent of reading, plus or minus 2 last single digits
- f. Transformers turns-ratio test equipment: 0.5 percent or better
- g. Ground electrode test equipment: plus or minus 2.0 percent of range
- h. Insulation (Megger) test sets: 0 - 1000V DC plus or minus 20 percent of reading at mid-scale for equipment 600 volts and less and 0 - 2500 volts DC plus or minus 20 percent of reading at mid-scale for equipment over 600 volts.
- i. Electrical load survey equipment
  - 1) Plus or minus 5 percent total error, including sensors
  - 2) 1 percent resolution
  - 3) Current transformers plus or minus 2 percent of range
  - 4) Voltage transformers plus or minus 0.5 percent of range
- j. Liquid dielectric strength test equipment: plus or minus 2 percent of scale
- k. Infrared scanning equipment: sensitivity of 2 degrees C
- l. Phase shifting equipment: plus or minus 1 degree over entire range
- m. High-current test equipment: plus or minus 2 percent of range
- n. DC high potential test equipment: plus or minus 2 percent of scale
- o. AC high potential test equipment: plus or minus 2 percent of scale
- p. Multi-amp SR-90, or equal, relay test set

## 2.02 SOURCE QUALITY CONTROL

- A. Provide in accordance with Division 01 General Requirements.

## **PART 3 – EXECUTION**

### **3.01 CONSTRUCTION REQUIREMENTS**

- A. All tests shall be performed with regard to protecting solid-state devices and electronic components from potential damage. Where applicable, disconnect solid-state devices and electronic components prior to applying testing voltage.
- B. Make up no connections at service entrance, transformers, substations, motors, motor control centers, and switchgear permanently until correct phase rotation of all equipment is determined and electrical tests have been completed. Install and insulate these connections temporarily, if necessary. Make permanent connections after proper rotation has been established and subsequent to completion of insulation resistance and dielectric tests.
- C. Wire and cable insulation resistance tests
  - 1. Low voltage, 600V maximum
    - a. Inspect wire and cables for physical damage and proper connection in accordance with approved Shop Drawings.
    - b. Check color-coding with Specifications and NEC standards.
    - c. Perform continuity test to insure proper connection.
    - d. Perform insulation-resistance test on each conductor with respect to ground and adjacent conductors. Applied potential shall be 1000 volts DC for 1 minute.
    - e. Evaluate test results by comparison with wires and cables of the same length and type. Investigate any values less than 50 Megaohms.
- D. Grounding Systems
  - 1. Verify that grounding system is in accordance with Specifications and applicable codes.
  - 2. The grounding system shall be tested for continuity of connection and for resistance to flow of current through ground connections.
    - a. The resistance between the main grounding electrode and ground shall be no greater than 5 ohms for 600V systems. For electrical substation grounds the ground resistance shall be no greater than 1 ohm.

- b. The ground resistance of conduits, equipment cases, and supporting frames shall be only fractionally higher than system ground.
- c. Method of measurement of ground resistance shall be as specified by NETA-AST and be approved by the Engineer before the start of tests.

E. Circuit Breakers - Low Voltage

- 1. Circuit breakers are to be checked for possible damage during shipment or storage.
- 2. Inspect the breaker visually for physical damage.
- 3. Perform several mechanical ON-OFF operations.
- 4. Perform circuit continuity check on each pole with the circuit breaker in the closed position.
- 5. Determine short-time pickup and delay, long-time pickup and delay by primary current injection.
- 6. Tests solid-state trip devices at multiple setting range of pickup and time delays.
- 7. Apply 300 percent of breaker rated continuous current to each pole to determine that the circuit breaker will trip on an overload.

F. AC Motors - Induction Motors

- 1. Inspect for physical damage and compare nameplate information with Drawings and Specifications
- 2. Inspect for proper installation, grounding, connection, and lubrication. Motor alignment, wiring capacity, speed and operation shall be checked to verify compliance with Specifications.
- 3. Check for unusual mechanical or electrical noise or signs of overheating during initial test run.
- 4. Perform insulation-resistance tests in accordance with ANSI/IEEE Standard 43. Test duration as recommended by NETA-ATS.
- 5. Perform insulation-resistance test on pedestal per manufacturer's instructions.
- 6. Perform insulation-resistance test on surge protection device in accordance with NETA-ATS Specifications.

7. Check resistance temperature detector (RTD) circuits for conformance with Drawings. Check that metering or relaying devices using the RTD's are of the proper rating.
8. Check that the motor space heater is operating.
9. Perform a rotation test to insure proper shaft direction if the motor has been electrically disconnected.
10. Measure running current and evaluate relative to load conditions and nameplate full-load amperes.
11. Check motor operation.
  - a. The motor shall be run for at least four-hours as close to full load as possible

G. Motor Control

1. Low and medium voltage motor controls shall be tested in accordance with NETA-ATS requirements and manufacturer recommendations.

H. Instrument Transformers

1. Inspect transformers for physical damage and nameplate information for compliance with Drawings and Specifications.
2. Verify proper connection of transformers with system requirements.
3. Verify tightness of all bolted connections and assure that adequate clearances exist between primary circuits to secondary circuit wiring.
4. Verify that all required grounding and shorting connections provide good contact.
5. Verify proper operation of transformer withdrawal mechanism (tip out) and grounding operation when applicable.
6. Electrical Tests - Current transformers
  - a. Perform insulation-resistance tests on current transformer secondary and wiring to-ground winding at 1000 volts DC for 1 minute. Value of test voltage on secondary wiring shall be 1000 volts DC for 1 minute. Do not perform this test with solid-state devices connected.
  - b. Perform a polarity test on each transformer winding, and verify manufacturer's polarity markings.

- c. Perform a turns-ratio verification test of each current transformer.
- d. The test data shall include the following:
  - 1) Manufacturer's stated ratio for each tap position
  - 2) Test turns ratio results
  - 3) Percent error per tap position
  - 4) Manufacturer's indicated polarity
  - 5) Test result polarity
- e. On each set of transformer windings, the turn's ratio shall be determined for all no-loads taps, using the two-voltmeter method for control transformers and the two-ammeter method for current transformers.
- f. Confirm test switch wiring and operation.
  - 1) A functional test shall be performed on the test switch of the current transformer to ensure that the secondary leads are shorted and that no open circuit conditions exist. A functional test shall also be performed on the control transformers to ensure that no short circuit exists across the secondary leads.
  - 2) All control wiring shall be checked to ensure proper operation of the device being powered.
- g. Perform other tests specified by the NETA-ATS as required by application.

7. Electrical Tests - Voltage Transformers

- a. Perform insulation-resistance tests on voltage transformers, winding-to-winding and windings-to-ground. Value of test voltage on secondary wiring shall be 500 volts DC for 1 minute. Do not perform this test with solid-state devices connected.
- b. Perform a polarity test on each transformer to verify the polarity marks or H1-X1 relationship as applicable.
- c. Perform ratio test as specified in NETA-ATS.
- d. Perform a dielectric withstand test on the primary windings with the secondary windings connected to ground. The DC dielectric

voltage shall be in accordance with Table Switchgear Insulation-Resistance Test Voltage above.

I. Metering and Instrumentation

1. Inspect all devices for physical damage and tightness of electrical connections.
2. Check calibration and accuracy of meters at 25/50/75/100 percent of full scale.
3. Verify all instrument multipliers.

J. Operating Tests

1. Mechanical and electrical interlocks

- a. Mechanical interlocks shall be examined to ensure the interlock is free to operate and that bearing surfaces are free to perform their intended function.
- b. Checks for correct adjustment of primary disconnect mechanisms in plug-in units. Shall be mechanically interlocked with the door to ensure that the door is held closed with primary disconnect in the ON position.
- c. Check for padlock provisions on disconnect operating mechanisms.
- d. Check motor starters equipped with a defeater mechanism to ensure that they can be operated to release the door interlock with the disconnect device in the ON position.

2. Circuit Breaker Operation

- a. Test trip all medium voltage circuit breakers from all devices in the trip circuit and verify operation of all interlocks.
- b. Installation and inspection of 480V power circuit breakers shall be in accordance with NEMA Pub. No. SG-3:
  - 1) Perform tests in accordance with NETA-ATS Specification and this Specification.
- c. Test all remote control stations for operation.
  - 1) A functional test shall be performed for all remote pushbutton stations and manual motor starters to ensure their proper operation.

- 2) Tests shall be as included in the appropriate standards.

### **3.02 FIELD QUALITY CONTROL**

- A. Provide in accordance with Division 01 General Requirements.

### **3.03 STARTUP & COMMISSIONING**

- A. Provide in accordance with Division 01 General Requirements.

### **3.04 CLOSEOUT ACTIVITIES**

- A. Provide in accordance with Division 01 General Requirements.

**END OF SECTION**

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## **SECTION 33 01 10.58**

### **DISINFECTION OF WATER UTILITY PIPING SYSTEMS**

#### **PART 1 – GENERAL**

##### **1.01 SUMMARY**

- A. Section Includes
  - 1. Provide disinfection of water utility piping systems in accordance with this Section and applicable reference standards listed in Article 1.03.

##### **1.02 PRICE AND PAYMENT PROCEDURES**

- A. Measurement and payment requirements: per Division 01 General Requirements.

##### **1.03 REFERENCES**

- A. Reference Standards
  - 1. American Water Works Association (AWWA)
    - a. AWWA B300 Hypochlorites
    - b. AWWA C651 Disinfecting Water Mains
    - c. AWWA C655 Field Dechlorination
  - 2. NSF International (NSF)
    - a. NSF/ANSI 60 Drinking Water Treatment Chemicals – Health Effects
    - b. NSF/ANSI 61 Drinking Water System Components – Health Effects

##### **1.04 ADMINISTRATIVE REQUIREMENTS**

- A. Coordination, sequencing, and scheduling: per Division 01 General Requirements.
- B. Perform disinfection after completing preliminary flushing of water utility piping systems, and after pressure and leakage testing of water utility piping systems are complete and approved by Engineer.
- C. Coordinate final flushing with Owner.

## 1.05 SUBMITTALS

- A. Submit in accordance with Division 01 General Requirements.
- B. Product data: Safety Data Sheets (SDS).
- C. Certificates
  - 1. Certificate of compliance verifying Owner laboratory performing bacteriological sampling analyses is certified with the state Department of Environmental Protection for analyzing public drinking water supplies.
  - 2. Certified bacteriological test results
- D. Source and field quality control submittals
  - 1. Disinfection procedures, including flushing locations, rates of flushing, discharge locations, chlorine form, method of chlorination, procedures for measuring potable water supply, procedures for measuring free chlorine residual, sampling locations and number and frequency of samples for bacteriological tests.
  - 2. Dechlorination plan
  - 3. Free chlorine residual test results
- E. Qualification statements: names and qualifications of personnel or firm performing disinfection and dechlorination work.
- F. Closeout and maintenance material submittals: per Division 01 General Requirements.

## 1.06 QUALITY ASSURANCE

- A. Provide in accordance with Division 01 General Requirements.
- B. Qualifications: per Division 01 General Requirements and as follows.
  - 1. Trained personnel or firm with minimum 5 years' experience with disinfection and dechlorination of water utility piping systems.
- C. Owner laboratory testing: bacteriological analyses by the Filtration Plant laboratory certified by the State Department of Environmental Protection for analyzing public drinking water supplies.

## 1.07 DELIVERY, STORAGE, AND HANDLING

- A. Provide in accordance with Division 01 General Requirements.

## **1.08 SITE CONDITIONS**

- A. Existing conditions: per Division 01 General Requirements.

## **PART 2 – PRODUCTS**

### **2.01 GENERAL**

- A. Chemicals in contact with raw or drinking water: per NSF 60 Drinking Water Treatment Chemicals – Health Effects.
- B. Products in contact with raw or drinking water: per NSF 61 Drinking Water System Components – Health Effects.

### **2.02 MATERIALS**

- A. Chlorine: liquid sodium hypochlorite or granular calcium hypochlorite conforming to AWWA B300.

### **2.03 SOURCE QUALITY CONTROL**

- A. Provide in accordance with Division 01 General Requirements.

## **PART 3 – EXECUTION**

### **3.01 DISINFECTION**

- A. Disinfect new water utility piping systems utilizing continuous-feed method in accordance with AWWA C651 before being placed into service.
- B. Utilize potable water from existing distribution system or other sources of supply approved by Owner.
- C. Prevent contaminated or highly chlorinated water from entering existing, new or previously disinfected water utility piping systems.
- D. Dechlorination procedures: in accordance with AWWA C655.
- E. Provide chemical feed pumps for chlorine solutions to provide accurate measurement of chlorine being introduced.
- F. Provide sampling taps in accordance with AWWA C651. Location of sample taps to be determined with Contractor, Owner, and Engineer during installation.
- G. Disinfect final connections to existing piping according to AWWA C651.

### **3.02 FINAL FLUSHING**

- A. Flush new water utility piping systems according to AWWA C651 following a minimum 24-hour disinfection retention period with a free chlorine residual of not less than 10 mg/l. Prevent contaminated or highly chlorinated water from entering existing, new or previously disinfected piping systems.
- B. Flush using water from existing mains. Coordinate flushing with Owner and take necessary measures to prevent damage or flooding to adjacent properties. Flushing velocities: minimum 3 feet per second in accordance with AWWA C651. Refer to AWWA C651 for required flow rates.
- C. After retention period described above, flush heavily chlorinated water using water from existing water mains. Coordinate flushing with Owner and take necessary measures to prevent damage or flooding to adjacent properties. Continuously flush heavily chlorinated water until background conditions are restored.
- D. Neutralize chlorine residual of disposed flushing water by chemical dechlorination according to AWWA C655. Provide equipment to dechlorinate at flushing rates indicated.
- E. Comply with Federal, State and local regulations for disposal of flushing water.

### **3.03 BACTERIOLOGICAL TESTS**

- A. Collect samples at each sampling location according to AWWA C651 after final flushing and before water utility piping systems are placed into service.
- B. Perform sampling according to Option A of AWWA C651 Section 5.1.1.1, unless otherwise approved by Owner.
- C. Passing laboratory results: absence of any coliform bacteria and heterotrophic plate count (HPC) less than 500/ml in both sets of samples.
- D. Re-flush and re-sample water utility piping systems if either set of samples fails to produce passing results according to AWWA C651. If resampling results fail, re-chlorinate, re-flush and re-sample according to AWWA C651 until passing results are obtained.

### **3.04 REPAIR/RESTORATION**

- A. Remove temporary blow-off and sample lines down to corporation stop once water utility piping system has been accepted and placed into service. Cap corporation stop.

### **3.05 FIELD QUALITY CONTROL**

- A. Provide in accordance with Division 01 General Requirements.
- B. Provide field testing of free chlorine residuals to ensure appropriate concentrations are being achieved during disinfection according to AWWAC651, and during flushing water disposal according to AWWA C655.

### **3.06 CLOSEOUT ACTIVITIES**

- A. Provide in accordance with Division 01 General Requirements.

**END OF SECTION**

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## SECTION 33 14 45

### PRE-FABRICATED WATER BOOSTER PUMP SKID

#### PART 1 – GENERAL

##### 1.01 SUMMARY

A. Section Includes

1. Furnish a factory built prefabricated tri-plex potable water booster pumping skid with necessary internal piping, pumps, motors, valves, electrical, instrumentation, and controls and other necessary appurtenances required for Site assembly of a complete and functional skid system in accordance with this Section, applicable reference standards listed in Article 1.03.
2. Deliver tri-plex booster pump skid complete to Project Site via 5-ft by 5-ft in ground hatch. No internal construction required except to install main electrical power service through service conduit provided, connect main water service to required points, and other Work specified, part of Contractor's installation requirements.
3. Design and performance requirements for prefabricated water booster pump skid.

B. Related Requirements

1. Section 33 01 10.58 – Disinfection of Water Utility Piping Systems

C. Contractor Installation Requirements

1. Complete installation, testing, and start-up, of the furnished tri-plex potable water booster pump skid.
2. Provide training of furnished items to Owner.

##### 1.02 PRICE AND PAYMENT PROCEDURES

- A. Measurement and payment requirements: per Division 01 General Requirements.

##### 1.03 REFERENCES

A. Reference Standards

1. American Iron and Steel Institute (AISI)
  - a. AISI S100 North American Specification for the Design of Cold-Formed Steel Structural Members

2. American National Standards Institute, Inc. (ANSI)
3. American Society of Mechanical Engineers (ASME)
  - a. ASME B16.1 Gray Iron Pipe Flanges and Flanged Fittings: Classes 25, 125, and 250
  - b. ASME B16.28 Wrought Steel Buttwelding Short Radius Elbows and Returns
  - c. ASME B16.5 Pipe Flanges and Flanged Fittings: NPS 1/2 through NPS 24, Metric/Inch Standard
  - d. ASME B16.9 Factory-Made Wrought Buttwelding Fittings
  - e. ASME B16.51 Copper and Copper Alloy Press-Connect Pressure Fittings
  - f. ASME B30.11 Monorails and Underhung Cranes - Safety Standard for Cableways, Cranes, Derricks, Hoists, Hooks, Jacks, and Slings
  - g. ASME HST-2 Performance Standard for Hand Chain Manually Operated Chain Hoists
  - h. ASME HST-3 Performance Standard for Manually Lever Operated Chain Hoists
  - i. ASME Boiler and Pressure Vessel Code (BPVC) Section IX Welding, Brazing, and Fusing Qualifications
4. ASTM International (ASTM)
  - a. ASTM A36 Standard Specification for Carbon Structural Steel
  - b. ASTM A53 Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
  - c. ASTM A105 Standard Specification for Carbon Steel Forgings for Piping Applications
  - d. ASTM A125 Standard Specification for Steel Springs, Helical, Heat-Treated
  - e. ASTM A181 Standard Specification for Carbon Steel Forgings, for General-Purpose Piping

- f. ASTM A234 Standard Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperature Service
- g. ASTM A 275/A 275M Standard Test Method for Magnetic Particle Examination of Steel Forgings
- h. ASTM A313 Standard Specification for Stainless Steel Spring Wire
- i. ASTM A500 Standard Specification for Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes
- j. ASTM A536 Standard Specification for Ductile Iron Castings
- k. ASTM A568 Standard Specification for Steel, Sheet, Carbon, Structural, and High-Strength, Low-Alloy, Hot-Rolled and Cold-Rolled, General Requirements for
- l. ASTM A1008 Standard Specification for Steel, Sheet, Cold-Rolled, Carbon, Structural, High-Strength Low-Alloy, High-Strength Low-Alloy with Improved Formability, Required Hardness, Solution Hardened, and Bake Hardenable
- m. ASTM B584 Standard Specification for Copper Alloy Sand Castings for General Applications
- n. ASTM C297 Standard Test Method for Flatwise Tensile Strength of Sandwich Constructions
- o. ASTM C645 Standard Specification for Nonstructural Steel Framing Members
- p. ASTM C754 Standard Specification for Installation of Steel Framing Members to Receive Screw-Attached Gypsum Panel Products
- q. ASTM C955 Standard Specification for Cold-Formed Steel Structural Framing Members
- r. ASTM C1007 Standard Specification for Installation of Load Bearing (Transverse and Axial) Steel Studs and Related Accessories
- s. ASTM D150 Standard Test Methods for AC Loss Characteristics and Permittivity (Dielectric Constant) of Solid Electrical Insulation
- t. ASTM D257 Standard Test Methods for DC Resistance or Conductance of Insulating Materials

- u. ASTM D412 Standard Test Methods for Vulcanized Rubber and Thermoplastic Elastomers - Tension
  - v. ASTM D543 Standard Practices for Evaluating the Resistance of Plastics to Chemical Reagents
  - w. ASTM D624 Standard Test Method for Tear Strength of Conventional Vulcanized Rubber and Thermoplastic Elastomers
  - x. ASTM D790 Standard Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials
  - y. ASTM D2244 Standard Practice for Calculation of Color Tolerances and Color Differences from Instrumentally Measured Color Coordinates
  - z. ASTM D4060 Standard Test Method for Abrasion Resistance of Organic Coatings by the Taber Abraser
  - aa. ASTM D4214 Standard Test Methods for Evaluating the Degree of Chalking of Exterior Paint Films
  - bb. ASTM D6380 Standard Specification for Asphalt Roll Roofing (Organic Felt)
  - cc. ASTM E84 Standard Test Method for Surface Burning Characteristics of Building Materials
  - dd. ASTM E96 Standard Test Methods for Gravimetric Determination of Water Vapor Transmission Rate of Materials
5. American Water Works Association (AWWA)
- a. AWWA C213 Fusion-Bonded Epoxy Coatings and Linings for Steel Water Pipe and Fittings
6. International Organization for Standardization (ISO)
- a. ISO/IEC 17025 General Requirements for the Competence of Testing and Calibration Laboratories
7. NACE International (NACE)/Society for Protective Coatings (SSPC) Joint Surface Preparation Standards
- a. NACE 2/SSPC-SP-10 Near-White Metal Blast Cleaning
  - b. NACE 3/SSPC-SP-6 Commercial Blast Cleaning

8. National Electrical Manufacturers Association (NEMA)
  - a. NEMA MG 1 Motors and Generators
9. National Electrical Code (NEC)
  - a. Article 310 Conductors for General Wiring
  - b. Article 430B Motor Circuit Conductors
10. Massachusetts Electric Code
11. NSF International (NSF)
  - a. NSF 61 Drinking Water System Components – Health Effects
12. UL Standards & Engagement (UL)
  - a. UL 61800-5-1 Adjustable Speed Electrical Power Drive Systems – Part 5-1: Safety Requirements – Electrical, Thermal and Energy

#### **1.04 ADMINISTRATIVE REQUIREMENTS**

- A. Coordination, sequencing, and scheduling: per Division 01 General Requirements.

#### **1.05 SUBMITTALS**

- A. Submit in accordance with Division 01 General Requirements.
- B. Product Data
  1. Manufacturer's specifications, product data, and materials of construction for individual components of water booster pump skid
  2. Complete listing of equipment and materials including components provided under other Specifications
- C. Shop Drawings
  1. Electronic files for pump skid layouts in AutoCAD format (.dwg)
  2. Water booster pump skid drawings drawn to scale in minimum of 3 different views, with illustration of the Massachusetts Electrical Code (MEC) clearances per section 110-26 of the MEC
  3. Pipe and Fittings
    - a. Piping layouts, schedules, dimensioned piping, fittings, location of valves and appurtenances and jointing details

- b. Methods and location of supports and technical specifications for complete piping system
  - c. Description of shop and field preparations, priming, painting, linings and coatings applied
- 4. Process and instrumentation diagrams (P&IDs) showing all equipment and instrumentation assigning a unique tag to components and associated input/output (I/O). Coordinate with Engineer to establish final tagging and equipment labeling format for the complete system.
- 5. Wiring and schematic diagrams required to demonstrate that the system has been coordinated and will properly function.
- D. Design Data
  - 1. Total weight of pumping skid, piping, valving and pumping equipment and equipment of the booster pump skid. Provide maximum localized loading in pounds per square feet.
  - 2. Provide data and calculations for piping and support design.
- E. Manufacturer installation manual including storage, transportation, leveling, alignment, wiring, pre-start, checklist, and initial startup procedures
- F. Certificates
  - 1. Provide NSF 61 certificate for each piece of equipment in contact with drinking water.
- G. Qualification statements
  - 1. Name of the factory service manager, telephone number with extension and number of years with the company.
  - 2. Name of each start-up service technician, and years of service with the company.
- H. Closeout and maintenance material submittals: per Division 01 General Requirements.
  - 1. Complete service manuals including copies of drawings, description of intended operation, Suppliers' detailed operation procedures, maintenance data and schedules, safety measures, and replacement parts lists
  - 2. Installation and operation manuals for all major control panel components, including the network switches, PLCs, I/O modules, communication equipment

3. Electronic copy (.DWG) of manufacturer's as-built record drawings of water booster pump skid and all components
4. Conformed to Construction record drawings of the control panel updated to reflect the panel after checkout and startup

## **1.06 QUALITY ASSURANCE**

- A. Provide in accordance with Division 01 General Requirements.
- B. Qualifications: per Division 01 General Requirements and as follows.
  1. Manufacturer with minimum 10 years' experience in manufacture, assembly, construction, start-up and maintenance of water booster pump skids, and minimum of 10 similar installations.
  2. Water booster pump skid manufacturer's representative: factory trained for a minimum of 5 prefabricated water pump skid installations.
- C. Certifications
  1. The pump skid manufacturer shall be required to demonstrate compliance with the Massachusetts Electrical Code (MEC) requirements for working clearances and wiring procedures. Equipment manufactured by an outside source or "brokered equipment" defined as systems not assembled on the premises of the named manufacturer by that company's employees will not be allowed.

## **1.07 DELIVERY, STORAGE, AND HANDLING**

- A. Provide in accordance with Division 01 General Requirements.
- B. Deliver equipment FOB Destination. Skid manufacturer maintains full responsibility for condition and completeness of equipment upon its delivery.
- C. Engineer reserves the right to inspect equipment prior to unloading and setting to assure quality and condition of equipment is in no way deficient.
- D. If in the view of Engineer or Engineer's inspector equipment is deficient when delivered, delivery will be refused.
- E. All spare parts shall be packed in containers bearing labels clearly designating the contents and respective pieces of equipment for which they are intended. All spare parts shall be delivered at the same time as the pertaining equipment.
- F. Store all equipment delivered and placed in storage with protection from the weather, humidity, temperature variations, dirt, dust, or other contaminants in accordance with the manufacturer's written instructions. Finished surfaces of all

exposed pump or pipe openings shall be protected by wooden blanks or other suitable covers to prevent foreign material and debris from entering the pumps.

- G. Prior to assembly, store equipment in accordance with manufacturer's instructions. Store electrical equipment in ventilated weatherproof enclosure. Utilize space heaters provided with equipment as recommended by equipment manufacturer.
- H. Off-load sections for assembly at the Site using equipment of sufficient size and design to prevent damage to the sections and equipment.
  - 1. Inspect items immediately after off-loading for shipping damage or missing parts. Identify damage or discrepancy in a written claim with the shipper prior to accepting delivery.
  - 2. Validate equipment serial numbers and parts lists with the shipping documentation and notify manufacturer of any unacceptable conditions identified to the shipper if required.

## **1.08 SITE CONDITIONS**

- A. Existing conditions: per Division 01 General Requirements and the Drawings.

## **1.09 WARRANTY**

- A. Provide manufacturer's warranty covering equipment, components and systems provided in or with the pumping skid providing for replacement and/or repair of faulty or defective components.

## **PART 2 – PRODUCTS**

### **2.01 PREFABRICATED WATER BOOSTER PUMP SKID**

- A. Comply with applicable reference standards listed in Article 1.03.
- B. Provide factory-assembled, modular structure of one compartment attached to station base structure and requiring no additional assembly at Project Site.
- C. Acceptable level of quality: equivalent to Synchroflo Tri-Plex Booster System (basis of design).
  - 1. Representative: Brian Glennon of Emerson Swan; telephone: (781) 986-2000.
- D. Alternate manufacturers may be considered, provided they take no exceptions to specifications.
- E. Specified Components

1. Within this Section and on the Drawings, certain components are listed by name and/or model number for at least one manufacturer's specific product. As such, no "or equal" is listed or allowed where at least one manufacturer is listed.
  2. These listed components have been chosen because of the Engineer's and Owner's knowledge of and experience with these listed components.
  3. No other components other than those listed are acceptable.
- F. Manufacturer's Responsibility for Performance
1. Contract Drawings for factory-built equipment do not necessarily include all details for design and fabrication for factory-built equipment.
  2. Drawings are generally schematic. Specifications call out requirements to known methods, components and assemblies to be included in complete and functional pumping skid.
  3. Manufacturer: responsible for functionality and operation of pump skid.

## **2.02 PUMP OPERATING CONDITIONS – BOOSTER PUMP SKID**

- A. Booster Pump Skid: capable of delivering fluid medium at the following capacities and heads when operating at 0 feet minimum suction pressure.
- B. Performance/Design Criteria
1. SynchroFlo Prefabricated Tri-plex booster pumping system
    - a. (3) NSF Certified EVMUG64-2 vertical multistage pumps formed 304 Stainless Steel with mechanical seal. Pump is close coupled to a 3600 RPM, TEFC, 3 Phase, 60 Cycle, 1.15 Service Factor, class F insulation, Premium Efficiency motor, which will meet or exceed NEMA MG-1 Table 12-12 for expected motor efficiencies.
    - b. (3) Suction Side, NSF Certified, lug style 150# Isolating butterfly valves
    - c. (3) Discharge Side, NSF Certified, lug style #150 Isolating butterfly valves
    - d. (3) Non-Slam, Wafer Style Check Valves
    - e. (1) Flanged, Stainless Steel Suction Header
    - f. (1) Flanged, Stainless Steel Discharge Header

- g. (1) Carbon Steel Split Skid and Bolted Panel Stand
- h. NEMA 12 control panel with the following standard options:
  - i. Single Main Power Feed
  - j. Individual Motor Circuit Breakers
  - k. Sequencing by Horsepower and/or Pressure-VFD speed sequencing
  - l. Customer Accessible data and fault logs
  - m. Mounted and wired Suction & System Discharge Pressure Transducers
  - n. Alarm horn
  - o. 7 Inch HMI Color Touchscreen with Compact Flash Drive Data Port
  - p. (3) Enclosure Mounted, Micro-Processor based Variable Frequency Drives
  - q. Serial Modbus 485 Slave RTU
  - r. Minimum 10,000 Amp SCCR rating
  - s. Ventilated and fan-cooled enclosure, with positive cabinet pressure
  - t. NSF Certified Polyurethane Tubing for Instrumentation and System Controls
  - u. (3) Mechanical Thermal Purge Valves
  - v. 132 Gallon Hydro Tank ( Remote Mounting )
  - w. (2) NSF System pressure gauges, 2.5" face dial, glycerin filled
- 2. Pumps 1, 2, and 3 design set points:
  - a. Two stage vertical pump
  - b. Pump Speed: 3600 rpm
  - c. Design Flow: 333 gpm
  - d. Total Design Head: 166 ft head
  - e. Minimum suction pressure: 40 psi
  - f. Motor: 460 V, 20 hp

## **2.03 PUMPS – MULTISTAGE VERTICAL TURBINE PUMPS**

- A. Surfaces shall be smooth and devoid of blow holes and other irregularities. Provide the following materials of construction for pump components as follows:
1. Intermediate and Suction Bowls: Class 30 cast iron
  2. Suction Bowl Lining: Porcelain-enamel
  3. Headshaft, Lineshaft, Bowlshaft and Couplings: 416 stainless steel
  4. Seal Housing and Bowl Bearings: Bismuth bronze
  5. Column Flange: Fabricated carbon steel
  6. Column Pipe: Fabricated carbon steel
  7. Column Bearing Retainers: 304 stainless steel
  8. Impellers: 316 stainless steel
  9. Lineshaft Bearing: EPDM
  10. Sand Collar: 304 stainless steel
  11. Discharge Head and Soleplate: Carbon steel
  12. Head Assembly Adjusting Nut: 316 Stainless Steel
  13. Pipe Plug: Cast iron
  14. Gaskets: Nitrile
- B. Suction Bowl
1. The suction bowl shall be designed to provide conservative entrance velocities and direct the flow to the first stage impeller. The inner surface of the suction bell shall be smooth and free of sharp projections which could cause turbulence or cavitation.
  2. The suction bowl shall have register fits for alignment and be connected by flanged and bolted construction.
  3. The bowl bearing and suction bell bearing shall have a high length-to - diameter ratio and shall be designed to support the bowl shaft above and below the first stage impeller. A sand collar shall be provided to prevent grit from entering the suction bell bearing.

4. Vortex plates to be provided.

C. Impellers

1. Impellers shall be machined and finished smooth and shall be balanced prior to assembly. The impellers shall be connected to the bowl shaft by means of a lock collet.
2. Impellers shall be provided with wear rings for clearance adjustment.

D. Column Assembly

1. The column shall include flanged or threaded connections and be of open design. Column sections shall not exceed the length previously specified, to ensure pump sections can be removed within the available height clearance in the pump installed location. Column shall be product lubricated.
2. The column shall be designed with drop-in bearing retainers. The interior of the column shall be free of offsets, burrs, discontinuities and irregularities.
3. The column bearing spacing shall be designed to ensure operation at a minimum of 25% above or below the first critical speed. Bearing spacing shall not exceed 5 feet.
4. The lineshaft shall be of adequate size to transmit the full power of the pump without slip or excessive vibration or elongation. Lineshaft shall have threaded joints, with left hand threads that tighten during pump operation. Lineshaft lengths shall not exceed 10 feet.

E. Discharge Head Assembly

1. The discharge head shall be designed to carry the entire weight of the complete pump and driver without distortion when spanning an opening of sufficient size to permit removal of the complete pump assembly. The discharge head shall be provided with a coupling guard and lifting lugs.
2. The discharge head shall be fitted with a flanged discharge connection. Flanges shall be 150 pound, flat faced flanges in accordance with ANSI B16.
3. A soleplate shall be provided for grouting and leveling the discharge head. Soleplate shall allow removal of the discharge head without disturbing grout below.

F. Stuffing Box Assembly

1. The seal housing shall be designed to accept a single split-type mechanical seal.

**2.04 PUMP/MOTOR VIBRATION ISOLATION PADS**

- A. Pump/motor assembly: mounted to fabricated steel base built specifically for pump/motor to be mounted.
1. Provide each mounting or attachment point complete with vibration isolation pad.
  2. Vibration isolation pad: 2-part, 1/4-inch base layer followed by 5/8-inch upper layer; nominal 2-inch by 2-inch square; for pump/motor combinations weighing up to 1500 pounds.

**2.05 PUMP MOTOR CONFIGURATION**

- A. Pump driver: NEMA Design B, three phase, alternating current, (squirrel cage) induction motor, continuous duty rated, with motor insulation as Class F for Class B Heat Rise.
- B. Motor efficiencies: Premium Efficient per NEMA MG 1, 2021 Part 12, Table 12-12 for motor enclosure, open or closed.
- C. Motor service factor: 1.15 on nameplate, reduced to 1.0 when used with variable frequency drives per NEMA MG 1 – 2021, Part 31.3.7.
- D. Motor enclosure: Open Drip Proof (ODP).
1. Motors of 600 volts or less: per NEMA MG 1 2021 Part 31.4.4.2 for ability to sustain voltage spikes when used with variable frequency drives under usual conditions.

**2.06 TRANSMISSION PIPING – STEEL PIPE**

- A. Piping 3 inches in diameter and above: steel, ASTM A53 (CW) for nominal pipe size 4 inch and smaller; and steel, ASTM A53 (ERW), Grade B for nominal pipe size 5 inch and larger.
- B. Steel butt-welding fittings: ASTM A234, Grade WPB, and dimensions and tolerances per ASME B16.9 and ASME B16.28, respectively.
- C. Forged steel flanges: ASTM A105 Class 60 and/or ASTM A181 for carbon steel forgings, and to dimensions and tolerances per ASME B16.5 for Class 150 and Class 300 flanges.

- D. Piping sizes: as indicated on Drawings.
  - 1. Size 10 inch and below: Schedule 40.
  - 2. Size 12 inch thru 20 inch: standard weight (0.375-inch wall).
  - 3. Size 24 inch and above: standard weight (0.500-inch wall).

## **2.07 PIPE WELDING**

- A. Pipe welds: performed by certified welders employed by pump skid manufacturer.

## **2.08 PIPE SURFACE PREPARATION**

- A. Prior to welding, prepare piping inside and outside surfaces by grit blasting, or other abrasive blasting, to minimum NACE 3/SSPC-SP-6 finish.

## **2.09 PIPE CUTTING**

- A. Piping of 4-inch diameter and smaller may be cut by saw.
- B. Piping of 6-inch diameter and larger: bevel cut. Utilize oxyfuel or plasma-arc cutting techniques to achieve bevel pipe cuts.

## **2.10 SADDLE CUTS AND WELDS**

- A. Utilize numerically controlled, plasma cutting machines to make saddle cuts in pipe made in preparation for saddle weld of pipe at an angle to pipe.
- B. Utilize numerically controlled, plasma cutting machines to make saddle end cuts to pipes to make saddle mating piece.
- C. When two saddle cut pieces are mated and welded with MIG process, make internal finished weld smooth and free of inclusions, crevices and other corrosion sites.

## **2.11 PIPE WELDING TECHNIQUES**

- A. Perform pipe welds by metal added, inert gas shielded arc welding (MIG) techniques wherein weld heat settings, wire feed speed, and traverse speed of Work below welding are numerically set to ensure proper weld fusion and penetration and repeatable welds.
- B. Utilize short circuit transfer, spray transfer or pulse-arc transfer modes of gas metal arc welding process.
  - 1. When utilizing short circuit mode, use shielding gas consisting of 50 percent carbon dioxide and 50 percent argon gas.

2. When utilizing spray or pulse-arc transfer modes, use shielding gas consisting of 5 percent carbon dioxide and 95 percent argon.
- C. Welding wire: minimum tensile strength 70,000 psi.
- D. Flange welds and butt welds of equal size pipe: single continuous nonstop weld around complete circumference of pipe.
  1. Apply vertical up weld passes to pipe welds whenever possible.
  2. No vertical down weld passes allowed.
- E. Do not allow internal obstruction, restriction, or create unintended sources of water deflection with completed pipe welded assemblies.
- F. Perform minimum 2 weld passes to complete each weld for piping 6 inches diameter and larger.
  1. First pass (root pass): applied at bottom of bevel cut using short circuit transfer welding mode.
  2. Second pass (cap pass): applied over root pass using spray or pulse arc transfer welding modes to ensure minimum total weld thickness equal to thinnest of two pieces being welded together.
- G. Pipe: sand blasted as specified, before pipe weld and after pipe weld, and before fusion bonded epoxy is applied.

## **2.12 WELD STANDOFFS**

- A. Do not perform welding on fusion-bonded coated piping after coating application has been completed.
- B. Where piping is to be welded after application of fusion-bonded epoxy coating to inside of pipe, provide weld standoff at point of weld.
  1. Weld standoff to pipe prior to coating.
  2. Perform weld to standoff and not onto pipe.

## **2.13 FUSION BONDED EPOXY INTERNAL PIPE COATING**

- A. Internal surfaces of piping to be fusion bonded coated: grit blasted to NACE 2/SSPC-SP-10 finish with finish profile required by coating material manufacturer.
- B. Internal, wetted surfaces of steel transmission piping: provided with fusion bonded epoxy coating applied to interior pipe surface.

1. Coating: applied per AWWA C213; in compliance with testing requirements of Table 1 and Table 2, with the exception of Table 2 Section 7.
2. Powder coating material: NSF 61 certified.

## **2.14 COATINGS – CORROSION PROTECTION**

- A. Interior and exterior surfaces of exposed steel structure, transmission piping, and fittings: grit blasted in accordance with NACE 3/SSPC-SP-6.
- B. Following fabrication, exposed surfaces of skid, interior and exterior: coated in accordance with the following requirements.
- C. Weldment Prime Coating
  1. Weldments: pretreated by hand to provide additional corrosion protection using same product as base coat.
  2. Following pretreatment, perform full coating application.
- D. Base Coating
  1. Apply base coating immediately after surface preparation.
  2. Base coating: two-component, high solids, high-build, fast drying epoxy system; self-priming and requiring no intermediate coatings; with excellent corrosion-resistant properties.
- E. Top Coating
  1. Apply full finish coating following base coating application.
  2. Top coating: two-component, high solids, high-build, fast drying epoxy system; self-priming and requiring no intermediate coatings; with excellent corrosion-resistant properties.
  3. Base and finish coats: total dry mil thickness 8.0 mils.
  4. Finish color: flint gray.
- F. Post-Assembly Coating
  1. Following assembly and just prior to shipping, thoroughly clean station floor and apply rolled-on two-part epoxy coating to cover scuffing or scaring that may have occurred during assembly.

## **2.15 SERVICE CONNECTIONS ON INTERNAL PIPING**

- A. Design plumbed devices within station eventually requiring service, such as meters, control valves, pumps and like equipment, to be easily removable from piping by the presence of appropriately placed and sufficient quantity of adaptors and couplings as shown on Drawings.
- B. Provide no less than quantity of couplings and adaptors shown.

## **2.16 RESTRAINING POINTS**

- A. Provide main inlet and outlet piping to station each with minimum 2 restraining points as welded on "eyes" or similar device welded to underside of base structure framing as shown to facilitate attachment of joint restraint tie rods or other device to be used in retarding any pipe movement at connections.

## **2.17 COMPRESSION COUPLINGS**

- A. Provide skid piping with variety of compression type, flexible couplings to prevent binding and facilitate removal of associated equipment.
  - 1. Location of couplings: per manufacturer design drawings.
  - 2. In lieu of compression coupling, flanged coupling adapter (FCA) may be used.
  - 3. Grooved fittings not allowed.
- B. Compression couplings or FCA, and flexible connectors/expansion joints: provided with minimum 2 zinc-coated steel threaded rods across the joint with appropriate bolted restraining points.

## **2.18 ELASTOMER PIPE CONNECTOR**

- A. Provide inlet side of each booster pump with elastomer connector to help isolate vibration and noise in piping system.
  - 1. Elastomer connector: single sphere design, constructed of neoprene and nylon with bias-ply tire reinforcing cord to provide 225 psi working pressure rating to minimum 120 degrees F. Elastomer connector to pass through plate steel flanges designed to grip connector so connector seals without gaskets when flange bolts are drawn up.
  - 2. Provide each pipe connector with control joint to limit pipe connector movement.

## 2.19 LINE PRESSURE GAUGES

- A. Type: combination pressure gauge with built-in pressure snubber; minimum 4-1/2-inch diameter face and turret style case; black fiberglass-reinforced thermoplastic with clear acrylic window with Buna-N gasket.
  - 1. Movement: rotary.
  - 2. Bourdon tube: copper alloy C-type.
- B. Provide gauge with 1/4-inch MNPT lower mount process connection and 0.6 mm copper alloy restrictor.
- C. Combination pressure gauge range and scale graduations: in psi and feet of water as follows.
  - 1. Gauge ranges: established by Engineer for each of the suction and discharge gauges for each pump station.
- D. Mounting of gauges: panel-mounted off pipeline and connected to their respective sensing point. Provide 1/4-inch ball valve or needle valve at each gauge connection for gauge isolation. Gauges mounted directly to pipeline or at sensing point not acceptable.
- E. Gauge trim tubing: complete with both isolating and vent valves; arranged to easily vent air and facilitate gauge isolation and removal.
- F. Gauge ranges, markings, and gauge location: per approved Shop Drawings.

## 2.20 PUMP PRESSURE GAUGES

- A. Provide each pump with two 4-1/2-inch pressure gauges, one each mounted to monitor pump suction nozzle and pump discharge nozzle. Provide each gauge with an isolation valve.
- B. Gauge taps, brass gauge cocks, isolation valves, and gauges: located upstream of check valve on discharge and downstream of isolating butterfly or gate valve on suction.

## 2.21 STATIC AND SENSING LINES

- A. All gauge, switch, and transmitter sensing lines: minimum 1/4-inch OD Type L rigid copper; run from sensing point and ball valve to point of device mounting.
- B. Alignment and organization of sensing lines: straight runs with 90-degree bends and continuously rising.

- C. Pilot tubing: run in workmanlike manner with right-angle bends and elastomeric mounting straps to securely hold tubing to be free of stress and vibration where required.

## **2.22 ELECTRICAL DESIGN, ASSEMBLY AND TESTING**

- A. Electrical apparatus and control panel design, assembly, installation, and integration of component parts: responsibility of manufacturer of record for booster pumping equipment.
  - 1. Manufacturer responsible for maintaining at his regular place of business a complete electrical design, assembly and test facility to assure continuity of electrical design with equipment application.
  - 2. Control panels designed, assembled or tested at other than regular production facilities or by other than regular production employees of manufacturer of record for booster pumping equipment not acceptable.

## **2.23 ELECTRICAL STANDARDS**

- A. Electrical control panels and mounting and installation: in accordance with UL 508A and NFPA 70.
- B. No exceptions to requirements of codes and standards allowed. Failure to meet specified requirements will be cause to remove equipment to correct violation.
- C. UL Listing
  - 1. Service entrance, power distribution, control and starting equipment panels: constructed and installed in accordance with UL 508A.
  - 2. Include Service Entrance (SE) rating on C-UL label stating that main distribution panel is suitable for use as service entrance equipment.
  - 3. Panels: shop inspected by C-UL or constructed in C-UL recognized facility, bearing serialized C-UL label indicating acceptance under UL 508A and under Enclosed Industrial Control Panel or Service Equipment Panel.
- D. ETL Listing
  - 1. Control panels: ETL listed by Interek Testing Services (ITS) under Industrial Control Panel (ICP) Category.
  - 2. Provide each completed control panel with ETL listing label stating that panel conforms to UL 508A and is certified to CAN/CSA C22.2 NO. 14. Listing label to include the station manufacturer's name, address and telephone number.

3. Inspections performed by ETL: performed quarterly at booster station manufacturer's facility to ensure listed products comply with report and procedural guide for products.

## **2.24 EQUIPMENT GROUNDING**

- A. Electrical equipment on booster skid: properly grounded per NEC Section 250. Items to be grounded include pump motor frames, control panel, transformer, convenience receptacles, dedicated receptacle for heater, air conditioner, dehumidifier, lights, light switch, exhaust fans and pressure switches.
- B. Ground wires from installed equipment: in conduit and leading back to control panel to copper ground buss specific for grounding purposes, and so labeled.
- C. Ground buss: complete with lug large enough to accept bare copper earth ground wire; serving as bond between earth ground and equipment ground wires.
- D. Pump Room
  1. Dedicated 2-inch wide by 1/4-inch-thick running copper ground bar for all equipment to be commonly grounded.
  2. Bar: offset from station wall and run perimeter of interior wall as necessary to easily install.
- E. Reference Division 26 Section 26 05 26 "Grounding and Bonding for Electrical Systems" for further requirements.

## **2.25 PANEL MOUNTING HARDWARE**

- A. Metal framing channel and hangers: used exclusively for mounting of electrical panels and electrical components, except those specifically designated otherwise.
- B. When mounting panels in buildings with 3/4-inch plywood interior sheathing, some panels and components may be mounted by screwing these devices into wall.
  1. Maximum weight of panel mounted with four lag screws: not exceeding 250 lb.
  2. Lag screws: 5/16-inch or 3/8-inch diameter and fully threaded.

## **2.26 ELECTRICAL SERVICE**

- A. Electrical service provided for booster pump skid: 480Y/277 volt, 3 phase, 60 Hertz, 4 wire.

## 2.27 ELECTRICAL APPARATUS – ADJUSTABLE FREQUENCY DRIVES

- A. General
  - 1. Design complete Variable Frequency Drive (VFD aka: VFD, AFD, ASD, Inverter, AC Drive, et al) for use with standard AC induction motor in water and wastewater applications.
  - 2. Design VFD to provide V/Hz or sensor-less vector mode of operation.
- B. VFD package: UL 61800-5-1 listed and CSA C22.2 NO. 274:17 listed as a complete assembly.
  - 1. Provide VFD in UL Type 1 (NEMA 12) listed enclosure rated for operation at ambient temperatures between -15 degrees C and 40 degrees C at altitude not exceeding 3,300 feet, with relative humidity less than 95 percent and no condensation allowed.
  - 2. VFD tolerated voltage window: designed to allow VFD to operate from line of + 30 percent nominal, and -35 percent nominal voltage as a minimum.
  - 3. VFD efficiency: 96.5 percent or better at full speed and load.
  - 4. Provide VFD with DC bus voltage controller to automatically maintain DC bus levels in high or low line conditions for purpose of maintaining full motor voltage at all times.
  - 5. Short-term normal duty overload current capacity: 110 percent of rated current for 1 minute out of 10 minutes.
- C. Provide VFDs with same customer interface, including digital display, and keypad, regardless of horsepower rating.
  - 1. Keypad: removable, capable of remote mounting and allow for uploading and downloading of parameter settings as an aid for start-up of multiple VFDs.
  - 2. Design control connections to remain consistent for all power ratings.
- D. Control panel: designed to include the following.
  - 1. Hand-Off-Auto selections and manual speed control.
  - 2. Drive to incorporate “bump-less transfer” of speed reference when switching between “Auto” and “Hand” modes.
  - 3. Capable of resetting VFD from control panel.

4. Include backlit LCD.
  - a. Display: in complete words, in a language selectable by user, for programming and fault diagnostics (alphanumeric fault codes not acceptable).
  - b. Provide with real-time clock with battery backup for adding time stamps to events, faults, warnings and also timer functions utilizing real-time clock.
  - c. Editable home-view in control panel to allow different customer specific configurations.
5. Dedicated “Help” button providing context sensitive assistance for programming and troubleshooting. Provide interactive assistants (wizards) to help commission and use drive.
6. Provide clear, interactive, context sensitive menu-based user interface to make it easy to adjust settings of drive.
7. Provide easy to use I/O menu, where user can see status and function of analog and digital inputs and outputs.
8. Control panel menu: containing diagnostic data about drive operation collected in a single location. Data to include data about active faults, warnings and events; and contain a summary of VFD active control sources.
9. User: capable of achieving the following.
  - a. Take screen capture snapshot of display with control panel and download screen capture to user’s computer for further purposes.
  - b. Connect PC tool with USB cable, without special tools, to control panel to set up and control VFD.
- E. Provide VFD with the following design features.
  1. 2 quick ramps that allow for quick acceleration and/or deceleration of pump motor.
  2. Pump cleaning feature to reduce build-up of debris on pump impeller; activated by every start or stop, when drive is in underload/overload condition, timed interval or digital input.
    - a. Cleaning cycle status: visible in panel screen when cleaning is active. VFD operates normally after cleaning cycle completed.

3. Torque boost for applications where increased torque needed for initial starting of pump motor.
4. Intelligent pump control (IPC) with multi-pump functionality and intelligent master/follower configuration for controlling up to 8 parallel pumps equipped with VFDs without additional modules; capable of level control, flow control, pressure control and pump alternation.
  - a. Include parameter synchronization feature to program PID, IPC and AI parameters in all parallel VFDs.
  - b. Functionality to start and stop pumps: based on capacity, operating time or efficiency of pump to ensure each pump is operated regularly.
5. Soft pipe filling functionality: used to fill empty pipe, by having programmable pipe fill time.
6. Programmable Sleep functionality for PID control in pumping systems to stop pump during low demand.
  - a. “Sleep Boost”: available to reduce short cycling of pump, designed to boost pressure or water level before pump shuts down to sleep.
7. PLC kind programming capability: available as standard.
  - a. Design to use different kinds of arithmetic, logical, selection, comparison and operation function blocks to monitor and control VFD, functions, inputs, outputs and variables.
  - b. Design to run different kinds of function block programs in different states and to set criteria, when to change state.
8. Real-time clock and calendar: available as standard for giving true time and date information to fault event history.
  - a. Real-time clock: capable of using with timed functions, to allow for controlling VFD and its functions based on time of day, day of the week, seasons of the year, holiday periods and holiday dates and special working periods and working days; and minimum 10 years power-off back-up without optional components.
  - b. Back-up battery: replaceable without opening VFD enclosure.
9. Make timed functions available to use for starting and stopping drive, selecting speed reference, selecting PID loop controller's set-point, controlling relay outputs, selection control location, giving the run permissive or interlock signal to VFD, etc. Include a boost function, which

allows starting VFD and/or its functions regardless of time of day, day of week, seasons or holidays.

10. VFD: capable of controlling induction motor, permanent magnet motor and synchronous reluctance motors as standard.
  - a. Maximum allowed motor cable length: 1,000 feet (300 meters).
  - b. Design VFD to commission induction motor, permanent magnet motor and synchronous reluctance motor with motor nameplate values only, without the need to get motor values from other sources.
11. Scalar and vector control modes: supported with independent control chains and parameters for both motor control modes.
12. Overload rating of VFD: 110 percent of its rated normal duty current for 1 minute every 10 minutes and with minimum of 130 percent for 2 seconds every 1 minute.
  - a. Overload ability: available at all times, not only at start.
13. VFD: capable of sensing loss of load (broken belt / broken coupling / dry pump) and signal loss of load condition. Design drive to be programmed to signal this condition via control panel warning, relay output and/or over serial communications.
  - a. Make relay outputs programmable for on/off time delays that will allow for drive acceleration or deceleration to and from zero speed, without signaling a false underload condition.
14. Make it possible to disconnect motor running full speed by opening optional contactor between motor and VFD without causing any damage to VFD.
15. Provide VFD with standard embedded functional safety feature, Safe Torque Off (STO), to make motor mechanically safe.
16. Provide VFD with energy optimization circuit (flux optimization) that will automatically reduce applied motor voltage to motor to reduce energy consumption by up to 10 percent and lower audible motor noise.
17. VFD: capable of starting into spinning load (forward or reverse) up to full speed and accelerate or decelerate to set-point (flying start) without tripping or component damage.
18. Design VFD to restart after power loss without the need to resend start command. Make this feature available regardless of control source, control panel, I/O or fieldbus.

19. Flux braking feature: available, where VFD controls motor to dissipate extra rotary energy as heat whenever braking is required; capable of decelerating motor from one speed to another, not only for stopping motor.
20. Power-Loss-Ride-Through: programmable.
  - a. If incoming supply voltage is cut off, VFD continues to operate using kinetic energy of rotating motor.
  - b. Drive continues to be operational as long as motor rotates and generates energy.
21. Switching frequency control function: provided to adjust switching or carrier frequency, based on actual VFD temperature; allows highest carrier frequency without de-rating VFD or operating at high carrier frequency only at low speeds (temperature fold-back). Design function to set both minimum and reference switching frequency.
22. Noise smoothing function: provided to distribute acoustic motor noise over range of frequencies instead of a single tonal frequency resulting in lower peak noise intensity.
23. Provide VFD with three programmable critical frequency or critical speed lockout ranges to prevent VFD from operating load continuously on an undesirable speed range (skip frequencies).
24. I/O terminals: color coded to simplify wiring and troubleshooting, with special mode for testing I/O and drive configuration without being connected to equipment.
  - a. Make I/O accessible (monitor and control) for fieldbus protocols (pass-through I/O).
  - b. Design: capable of monitoring status of I/O from VFD's control panel.
25. Provide VFD with at least two programmable analog inputs.
  - a. Both inputs: designed to accept current (0 to 20 mA or 4 to 20mA) or voltage (0 to 10 VDC) signals.
  - b. Signal type selection, voltage or current: made via VFD user interface.
  - c. DIP-switches or jumpers not allowed for input type programming.
  - d. Analog Input

- 1) Designed with not more than 1 percent inaccuracy of full scale in both current and voltage modes.
    - 2) Programmable to be used as speed reference, frequency reference, pressure monitor, PID loop controller's set-point reference or signal feedback, or other defined inputs.
  - e. If analog input reference (4 to 20 mA or 2 to 10 VDC) is lost, VFD to give user the option of: (1) stopping and displaying fault; (2) running at programmable preset speed and displaying an alarm; (3) hold VFD speed based on last good reference received and displaying an alarm. Program drive to signal this condition via control panel warning, relay output and/or over serial communication bus.
26. Provide VFD with at least two programmable analog outputs (0 to 20 mA or 4 to 20 mA); out of which one to be software configurable to be either voltage (0 to 10 VDC) or current output.
- a. Analog Output
    - 1) Designed with not more than 1 percent inaccuracy of full scale in both current and voltage modes.
    - 2) Programmable to give output signal proportional to frequency, motor speed, output voltage, output current, motor torque, motor power, DC bus voltage, active reference or other defined data.
27. Provide VFD with at least six programmable digital inputs (24 VAC and 12 to 24 VDC, PNP or 5 pcs NPN) to connect to external devices, as follows.
- a. Make inputs configurable for PTC sensors.
  - b. Provide one programmable run permissive circuit.
  - c. Provide up to four programmable free text interlock inputs.
  - d. Provide at least one digital input which can be configured to receive pulse signal up to 16 kHz.
28. Provide VFD with at least three programmable digital Form-C relay (changeover) outputs. Relays to include programmable on and off delay times and adjustable hysteresis.
29. Provide VFD with EIA-485 (RS-485) port for serial communications as standard.

- a. Equip VFD with built-in fieldbus communication of type Modbus RTU.
    - b. EtherNet/IP, Modbus/TCP, DeviceNet, PROFIBUS-DP, PROFINET protocols: available as plug-in and inbuilt options.
  - 30. Provide VFD with integral 5 percent impedance line reactors to reduce harmonics to power line and to add protection from AC line transients.
    - a. 5 percent impedance may be from dual (positive and negative DC buss) reactors, or 5 percent AC line reactors.
    - b. Add AC line reactors to VFDs with only one DC reactor.
  - 31. VFDs through 50 hp: protected from input and output power mis-wiring. Design VFD to sense this condition and display an alarm on keypad.
- F. Variable Frequency Drive Units: ABB Group Model ACQ580.

## **2.28 DRIVE FUSE PROTECTION**

- A. Provide fuse protection in accordance with drive manufacturer's installation guidelines and as required in UL 61800-5-1.

## **2.29 HARMONIC MITIGATION**

- A. Equip PWM AC variable frequency drives with harmonic mitigation equipment.
  - 1. Harmonic mitigation equipment and components: manufactured and tested in accordance with the latest applicable standards of UL and NEMA.
  - 2. Make demonstration of compatibility between harmonic mitigation equipment and VFD available upon request by Owner or Engineer.
- B. Provide harmonic mitigation equipment that treats all characteristic low frequency harmonics generated by 3-phase, diode bridge rectifier load (5th, 7th, 11th, 13th, etc.).
  - 1. Characteristic harmonics: suppressed without the need for individual tuning or requirement to phase shift against other harmonic sources.
- C. Harmonic mitigation: by passive inductor/capacitor network. Active electronic components not allowed.
- D. Power factor: 0.98 lagging to 0.95 leading in operating range from full to half load.

1. To ensure compatibility with engine generators, do not allow harmonic mitigation equipment to introduce capacitive reactive power (KVAR), which is greater than 20 percent of its kVA rating.
  2. Do not allow harmonic mitigation equipment to resonate with system impedances or attract harmonic currents from other harmonic sources.
- E. Harmonic mitigation equipment in combination with VFD: in compliance with requirements of IEEE 519 for individual and total harmonic voltage and current distortion.
1. Point of Common Coupling (PCC) for all voltage and current harmonic calculations and measurements: input terminals to harmonic mitigation equipment.
- F. Total Harmonic Voltage Distortion (THVD): not exceeding 5 percent and limiting individual harmonic voltage distortion to less than 3 percent, in compliance with requirements of Table 10.2 of IEEE 519.
1. Limits apply while operating on either utility supply or generator supply when applicable.
  2. Harmonic mitigation equipment vendor not responsible for pre-existing voltage distortion caused by other harmonic sources.
- G. Total Demand Distortion (TDD) of current at input terminals of harmonic mitigation equipment: not exceeding limits as defined in Table 10.3 of IEEE 510.
1. For  $I_{sc}/I_L$  ratio  $< 20$ : less than 5 percent.
  2. For all other  $I_{sc}/I_L$  ratios: not exceeding 8 percent, even when Table 10.3 allows for more relaxed limits.
  3. For single-phase applications: not exceeding 12 percent.
- H. Full load efficiency of harmonic mitigation equipment/VFD combination: greater than 96 percent. Provide harmonic mitigation equipment itself with efficiency no less than 99 percent.
- I. Acceptable level of quality: equivalent to Mirus International, Inc. Lineator AUHF.

## **2.30 ELECTRICAL DEVICES**

- A. Multi-position switches including Hand-Off-Automatic switches: oil tight, 3 position maintained, and located on main control panel door.
- B. Indicating lights: oil tight, with full voltage, LED pilot light.

- C. Provide nameplates on panel front mounted switches and lights.
- D. Switches, Lights and Pushbuttons
  - 1. Acceptable level of quality: equivalent to Schneider Electric Series XB, 22 mm, die cast chrome plated devices.
    - a. Pilot lights: protected LEDs for 120 Vac operation as XB4BVG.
    - b. Pushbuttons: non-illuminated, momentary contact, extended lens as ZB4BL.
    - c. Switches: 2 position maintained, 2 position right-to-left, 3 position maintained, 3 position momentary-to-center, 3 position momentary from left to center, and 3 position momentary from right to center with standard black lever as ZB4BD.
- E. Switches
  - 1. Booster Pump #1: Hand-Off-Auto, 3-position
  - 2. Booster Pump #2: Hand-Off-Auto, 3-position
  - 3. Booster Pump #3: Hand-Off-Auto, 3-position
  - 4. Booster Pump #1: Telemetry-Test, 2-position
  - 5. Booster Pump #2: Telemetry-Test, 2-position
  - 6. Booster Pump #3: Telemetry-Test, 2-position
- F. Lights
  - 1. Red: High Discharge Pressure
  - 2. Red: Low Suction Pressure
  - 3. Green: Booster Pump #1 in Operation
  - 4. Green: Booster Pump #2 in Operation
  - 5. Green: Booster Pump #3 in Operation
  - 6. Red: Booster Pump #1 Failure
  - 7. Red: Booster Pump #2 Failure
  - 8. Red: Booster Pump #3 Failure

- G. Control panel door: complete on interior with stick-on transparency containing "as-built" reproduction of electrical control panel schematic.
  - 1. Wiring diagram: corrected "as built" copy; containing individual wire numbers, circuit breaker numbers, switch designation and control function explanations.
- H. Panels: in compliance with UL 508A.
  - 1. Provide panels with C-UL 508A label, clearly displayed in appropriate location within panel.
  - 2. C-UL 508A listing: in name of equipment manufacturer.
- I. Enclosures: NEMA 12 for indoor and NEMA 4 for outdoor location; fabricated from minimum 14-gauge cold-rolled steel with baked enamel finish in manufacturer's standard color.
  - 1. Provide units with single gasket front door and hinges, locking hasp and door clamping hardware.
- J. Wiring: in conformance with NEC, state, local and NEMA electrical standards.
  - 1. Incoming and outgoing wires: connected to numbered terminal blocks with wiring neatly tied and fastened to chassis as required.

## **2.31 OPERATION DESCRIPTION FOR PLC BASED AND VFD CONTROLLED PUMPING SYSTEM**

- A. Provide single NEMA 12, 14-gauge type painted steel gasketed enclosure, with lockable handle operated three-point latching door mechanism. Control panel to house PLC, OIT, UPS, Ethernet switch.
  - 1. PLC: Allen Bradley CompactLogix 5380 Series PLC with 5069 based I/O modules.
  - 2. OIT: Automation Direct C-more EA9 Series 15-inch color LCD touch screen.
- B. Provide space and 24VDC circuit for Owner-supplied ethernet switch (to be field installed).
- C. Provide control panel with 24VDC UPS, din-rail mounted.
  - 1. Provide UPS with remote monitoring features with contact outputs, connected to PLC to indicate UPS fault and low battery conditions.

2. Acceptable level of quality equivalent to Allen Bradey SOLA, Phoenix Contact.
- D. 120VAC Surge Suppression
1. Provide incoming 120VAC power source for control panel with surge suppression located in control panel.
  2. Provide surge suppressor with auxiliary contact, connected to PLC to indicate surge suppressor failure.
- E. Control Panel Overcurrent Protection
1. Overcurrent protection devices: sized to protect associated devices and loads.
  2. Circuit breakers: sized to protect associated equipment and provide necessary power to operate.
- F. DC Power Supply
1. Din-rail mounted power supply: housed in rugged metal case with large, accessible, multiple connection screw terminals.
  2. Power supply: enclosed and finger safe. Open power supplies not acceptable.
  3. Power supply features: auto selecting 115/230VAC, 50/60 Hz single phase input, adjustable voltage, power factor correction, short circuit, overvoltage and over-temperature protection; 90 percent or greater efficiency.
- G. Wiring: terminated onto single-or-double tier terminal blocks, where each terminal is sequentially numbered with unique identifier. Arrange terminal blocks in vertical rows and separate into three groups – power, alternating current (AC) control, and DC signal.
1. Terminal blocs: compression screw type.
  2. Clearly tag and color code wiring in accordance with NEC.
  3. Power wiring, control wiring, grounding, and DC wiring: provided with different color insulation for each wiring system used.
- H. Provide control panel with input configured to alarm upon loss of main control panel power.

## 2.32 ALARMS CONDITION AND OUTPUT

- A. Provide the following alarms/status points within the booster pump station and wire back to station's control panel.
  - 1. Provide indication for AUTO position of HAND-OFF-AUTOMATIC selector switches on pumps.
  - 2. VFD failure alarm: logic provided for detection, indication and alarm of failure of each VFD.
  - 3. Pump-call-to-run alarm: pump operation directly determined by closure of dry contacts within SCADA provider's control panel.
  - 4. Pump VFD speed reference: VFDs speed input wired to interface panel for 4-20mA speed reference signal as provided by SCADA provider's control panel.
  - 5. Pump VFD speed feedback: VFDs speed feedback wired to interface panel for 4-20mA speed feedback signal as provided to SCADA provider's control panel by VFD.
  - 6. Phase fail/power status alarm: provided by 120-volt AC relay.
  - 7. Surge pressure low alarm: low surge discharge pressure alarm provided by pressure switch mounted on suction header.
  - 8. Surge pressure high alarm: high surge discharge pressure alarm provided by pressure switch mounted on discharge header.
  - 9. Suction pressure: provided by input from suction pressure transmitter.
  - 10. Discharge pressure: provided by input from discharge pressure transmitter

## 2.33 PUMP MOTOR RUN TIME METER

- A. Control panel: containing one running time meter provided for each pump to show cumulative number of hours of operation.
- B. Meter: enclosed in dust and moisture proof molded plastic case, suitable for flush mounting on main control panel; suitable for operation from 115 volt, 60 cycle supply.
- C. Provide meter dial that registers in hours and tenths of hours up to 99999.9 hours before repeating.

## 2.34 ELECTRICAL PHASE MONITOR

- A. Provide UL approved phase monitor to protect three-phase equipment against phase loss, undervoltage and phase reversal conditions.
  - 1. When fault is sensed, monitor output relay opens within two seconds or less to turn equipment off and/or cause an audio or visual alarm.
  - 2. Both Delta and Wye systems may be monitored.
- B. Provide monitor with automatic reset and include adjustable voltage delay.
- C. Provide monitor with indicator LED (glows when all conditions are normal) that monitors phase sequence: ABC operate (will not operate CBA).

## 2.35 ELECTRICAL CONDUIT AND WIRING

- A. Wiring within equipment enclosure and outside of panel enclosures: run in conduit except where watertight flexible conduit is properly used to connect pump motors, fan motors, transformers, solenoid valves, limit switches, etc., where flexible connections are best utilized.
- B. Devices and appliances, provided by original manufacturer and equipped with UL approved rubber cord and plug, may be plugged into receptacle.
- C. Equipment enclosure conduits: rigid aluminum, minimum size 3/4-inch or larger, sized to handle type, number and size of equipment conductors to be carried.
- D. Conduiting: in compliance with Article 347 of NEC and NEMA TC 2, Federal WC 1094A and UL 651.
- E. Conduit where flexible conduit connections are necessary: liquid tight, flexible, totally nonmetallic, corrosion resistant, nonconductive, UL listed conduit sized to handle type, number and size of equipment conductors to be carried; in compliance with Article 351 of NEC.
- F. Motor circuit conductors: sized for load.
  - 1. Branch circuit conductors supplying single motor of one horsepower or more: ampacity of not less than 125 percent of motor full load current rating, dual rated type THHN/THWN, as set forth in Articles 310 and 430B of NEC, Schedule 310 13 for flame-retardant, heat-resistant thermoplastic, copper conductors in nylon or equivalent outer covering.
- G. Control and accessory wiring: sized for load, type MTW/AWM (machine tool wire/appliance wiring material) per Articles 310 and 670 of NEC, Schedule 310 13 and NFPA 79 for flame retardant, moisture-, heat- and oil-resistant thermoplastic, copper conductors in compliance with NTMA and as listed by UL (AWM), except

where accessories are provided with manufacturer-supplied UL-approved rubber cord and plug.

- H. Reference Division 26 Sections 26 05 19 “Low-Voltage Electrical Power Conductors and Cables” and 26 05 33 “Raceways and Boxes for Electrical Systems” for further requirements.

## **2.36 INSTRUMENTS – GAUGE PRESSURE TRANSMITTERS**

- A. Provide pressure transmitters to measure pump skid suction and discharge pressure. Design transmitters to sense gauge pressure and transmit 4-20 mA DC signal. Instruments to measure pressure of predetermined span.
  - 1. Range: fixed at 0-600 psi.
  - 2. Accuracy: not more than plus or minus 0.05 percent of span.
- B. Transmitter design features include the following.
  - 1. Analog output and standard LCD with touch control and Bluetooth to provide Intelligent transmitter.
  - 2. One-line digital indicator to display measurement in any selected units.
  - 3. Protected by gasketed, weatherproof IP66 and IP68 enclosure.
  - 4. 1/4-inch NPT female threaded tapping ports.
  - 5. Process-wetted parts of each instrument: Type 316L stainless steel.
- C. Manufacturer and Model
  - 1. Endress+Hauser USA Model PMP71B
  - 2. Foxboro Series IGP05
  - 3. Rosemount Model 2088G2S22A1M7B4S5
  - 4. Or equal

## **2.37 SOURCE QUALITY CONTROL**

- A. Provide in accordance with Division 01 General Requirements. Comply with applicable reference standards listed in Article 1.03.
- B. Tests and Inspections
  - 1. Pressure Testing

- a. Once station plumbing is completed, hydrostatically test pressure piping within the skid including valves, pumps, control valves, fittings, and connections that make up system, at pressure of 150 psi or pressure equal to lowest test pressure rating of equipment within tested system, whichever is lesser pressure.
  - b. Apply test pressure for minimum 20 minutes and check time joints, connections, and seams for leaks.
  - c. Repair deficiencies found and retest system.
  - d. Transmit testing results, signed by Quality Control Manager or test technician, in writing to Engineer prior to shipment of skid. Note test pressure and time at full pressure.
2. Factory Performance Testing
    - a. Harmonic mitigation: factory tested by manufacturer for harmonic mitigating performance and energy efficiency under actual variable frequency drive loads.
    - b. A detailed description of the program and a sample test report must be provided at time of quotation.

## **PART 3 – EXECUTION**

### **3.01 EXAMINATION**

- A. Verify Site conditions prior to installation of pre-fabricated pump skid.

### **3.02 PREPARATION**

- A. Provide a minimum of 30 days' notice of the anticipated delivery date of pump skid to the Engineer and Owner.

### **3.03 INSTALLATION**

- A. Sequence: in accordance with Division 01 General Requirements.
- B. Coordinate with pump skid manufacturer for transfer of prefabricated pump skid from delivery truck, and installation on Site.
- C. Coordinate with Engineer (Owner's SCADA integrator) to connect water booster pump skid to Owner's existing SCADA network.

### **3.04 FIELD QUALITY CONTROL**

- A. Provide in accordance with Division 01 General Requirements.

B. Manufacturer Field Services

1. Provide as specified in each individual equipment Specification section.
2. Coordinate with Owner and Engineer in advance of manufacturer's field services. Coordinate anticipated dates of presence on Site with Owner and Engineer at least 30 days in advance.
3. Summary of Manufacturers' Field Services (minimum)

| Specification Section | Equipment   | Type of Services                          | Time (8-hour days) |
|-----------------------|-------------|-------------------------------------------|--------------------|
| 33 14 45              | Pump Skid   | Testing and Vendor Training               | 8-hour day         |
| 33 14 45              | Instruments | Test for proper termination and operation | 8-hour day         |

4. Training
  - a. Provide operations training in accordance with Division 01 General Requirements.
  - b. Provide two 4-hour general operation training sessions.
  - c. Pump skid Supplier representatives to conduct the initial training session based on training modules prepared by pump representatives.

**3.05 STARTUP & COMMISSIONING**

- A. Provide in accordance with Division 01 General Requirements.
1. Perform startup of mechanical, process, electrical, plumbing and instrumentation control equipment as specified in individual Specification sections.
  2. Conduct startup and commissioning of mechanical process, electrical, ventilation, and instrumentation systems required for full and complete water booster pump skid operation, including SCADA connections from water booster pump skid to Owner's existing control panel.
    - a. Reference Division 26 Section 26 08 00 "Commissioning of Electrical Systems" for further requirements.

3. Disinfect piping prior to startup and commissioning per Section 33 01 10.58.
4. Flow meter installation checkout: completed in advance of pump testing.
5. Controls (including PLC and OIT): tested to demonstrate that each function of the control system operates as specified in both manual and automatic modes. Operate controls continuously in automatic mode for a 24-hour period without interruption.
6. Provide a start-up service report following testing, start-up, and training.
7. Repair damaged shop coatings to maintain coating integrity per manufacturer's requirements.

### **3.06 FIELD TESTING - PUMPS**

- A. The startup and demonstration period for the equipment previously specified shall include the following:
- B. Prior to acceptance, perform an operational test of all equipment, drivers, and control systems to determine if the installed equipment meets the purpose and intent of the specifications. Tests shall demonstrate that the equipment is not electrically, mechanically, structurally, or otherwise defective; is in safe and satisfactory operating condition; and conforms to the specified operating characteristics. Prior to applying electrical power to any motor driven equipment, the drive train shall be rotated by hand to demonstrate free operation of all mechanical parts. Tests shall include checks for excessive vibration, leaks in all piping and seals, correct operation of control systems and equipment, proper alignment, and power consumption.
- C. Provide all requirements to conduct a proper field test which include but are not limited to power, water, facilities, labor, materials, supplies and test instruments.
- D. In the presence of the Manufacturer's representative, the Contractor shall test and inspect all necessary controls which include but are not limited to all VFD set points and interlocks (Casing High Temperature) required for the equipment to function properly without causing damage to the equipment. The Manufacturer's representative shall provide the Contractor and Engineer with the necessary set points in writing prior to the site acceptance test visit as outlined in the submittals. Initial testing of the system shall be with water. Wastewater shall not be used for initial testing.
- E. Provide Field Test Booklets for each system showing all field tests performed to adjust each component and all field tests performed to prove compliance with the specified performance criteria, upon completion and testing of the installed system.

- F. Field testing shall demonstrate that all controls and systems function properly. A successful field test shall include “Continuous” operation of each pump for a minimum period of three (3) hours without alarms or shutdowns, except as intended for testing. During testing the following items shall be measured at five (5) points over the entire operating range:
1. Discharge Head
  2. Suction Head
  3. Capacity
  4. Pump Speed
  5. Amperage Draw

### **3.07 RETESTING**

- A. If the equipment does not successfully pass the tests listed above, the Manufacturer shall repair the equipment and perform the tests again until passing the tests successfully. If any deficiencies are revealed during any test, such deficiencies shall be corrected, and the tests shall be reconducted at no additional cost to the Owner.

### **3.08 CLOSEOUT ACTIVITIES**

- A. Provide in accordance with Division 01 General Requirements.

**END OF SECTION**

## x34



12 Mountfort Street  
Portland, Maine 04101  
800.426.4262 | [www.woodardcurran.com](http://www.woodardcurran.com)

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# ISSUE FOR BID



CLIENT INFO:

CITY OF WORCESTER  
WATER FILTRATION PLAN,  
WORCESTER, MA

# POTABLE WATER BOOSTER PUMP REPLACEMENT

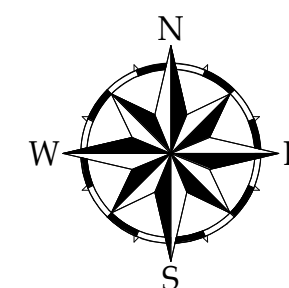
| REV          | MM/DD/YY    | DESCRIPTION |
|--------------|-------------|-------------|
| JOB NO:      | 0234978.01  |             |
| DATE:        | AUGUST 2026 |             |
| SCALE:       | AS NOTED    |             |
| DESIGNED BY: | HC          |             |
| DRAWN BY:    | WNW         |             |
| CHECKED BY:  | JM          |             |
| FILENAME:    |             |             |

DRAWING TITLE:

# COVER SHEET

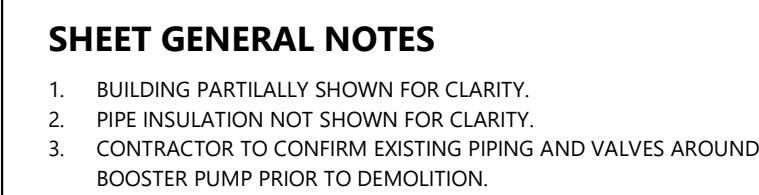
DRAWING NO:

**G.2-00-000**



## SITE LOCATION MAP

### 3D ISOMETRIC VIEW



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**ISSUE FOR BID**

CLIENT INFO:

CITY OF WORCESTER  
WATER FILTRATION PLAN,  
WORCESTER, MA

## POTABLE WATER BOOSTER PUMP REPLACEMENT

[illegible]

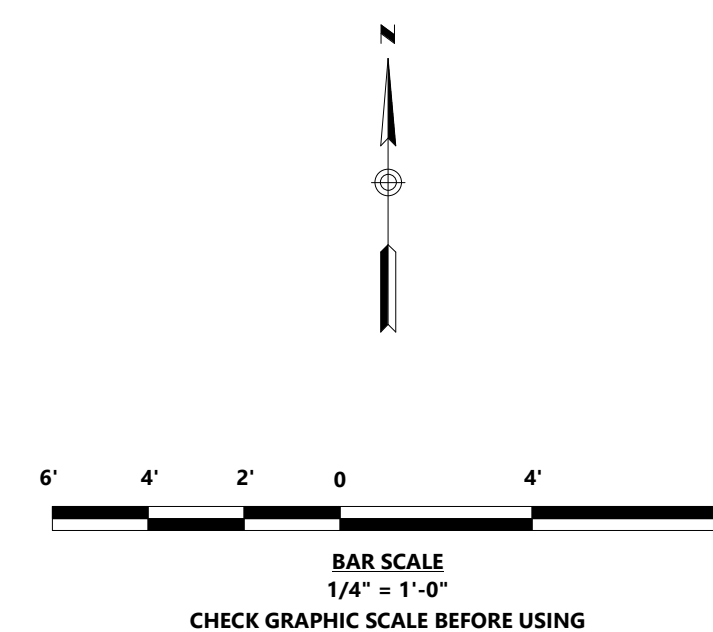
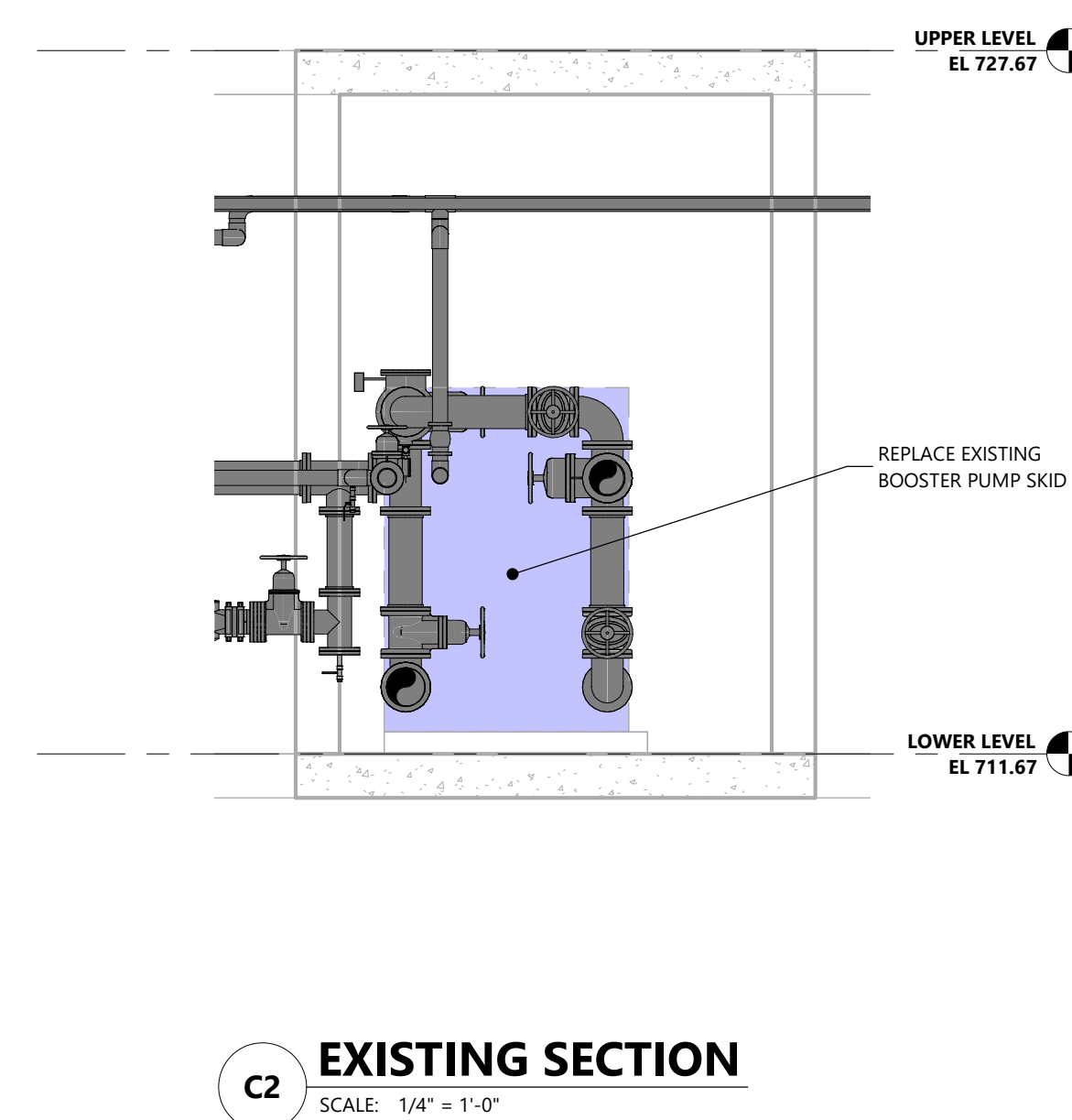
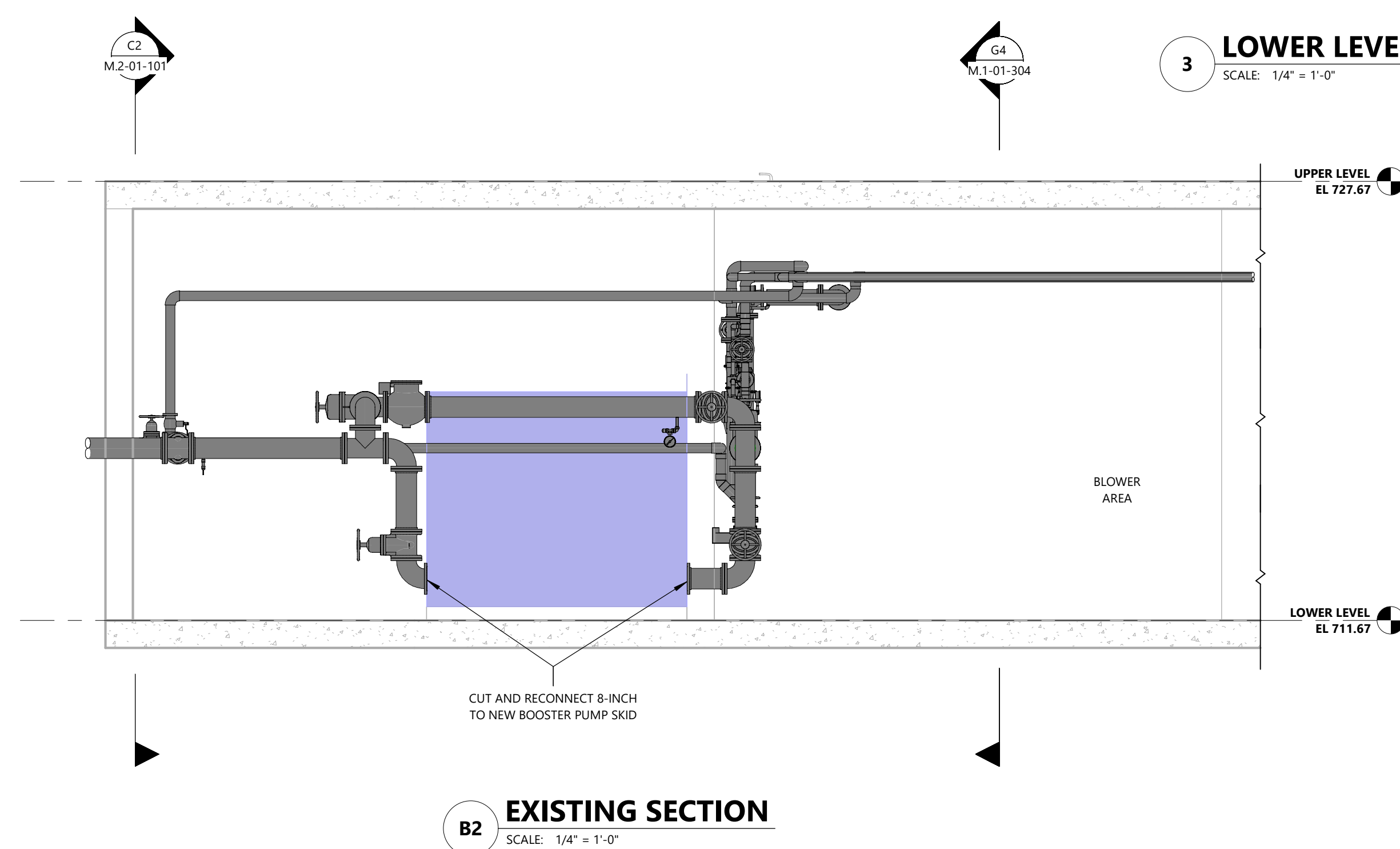
| REV          | MM/DD/YY     | DESCRIPTION |
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| JOB NO:      | 0234978.01   |             |
| DATE:        | AUGUST 2026  |             |
| SCALE:       | 1/4" = 1'-0" |             |
| DESIGNED BY: | HC           |             |
| DRAWN BY:    | WNV          |             |
| CHECKED BY:  | JM           |             |
| FILENAME:    |              |             |

DRAWING TITLE:

**MECHANICAL  
BOOSTER PUMP SKID  
REPLACEMENT PLAN AND  
SECTION VIEW**

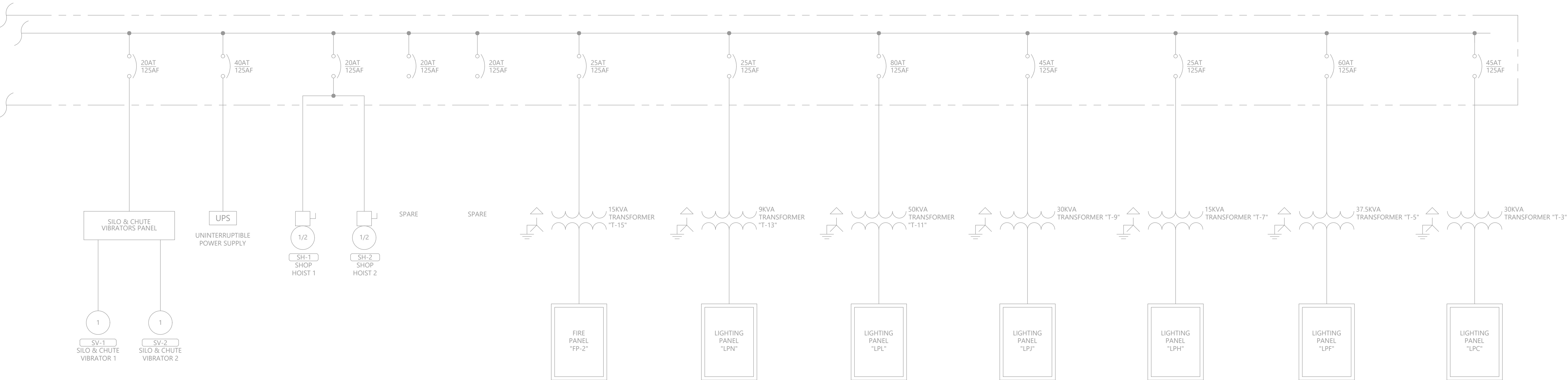
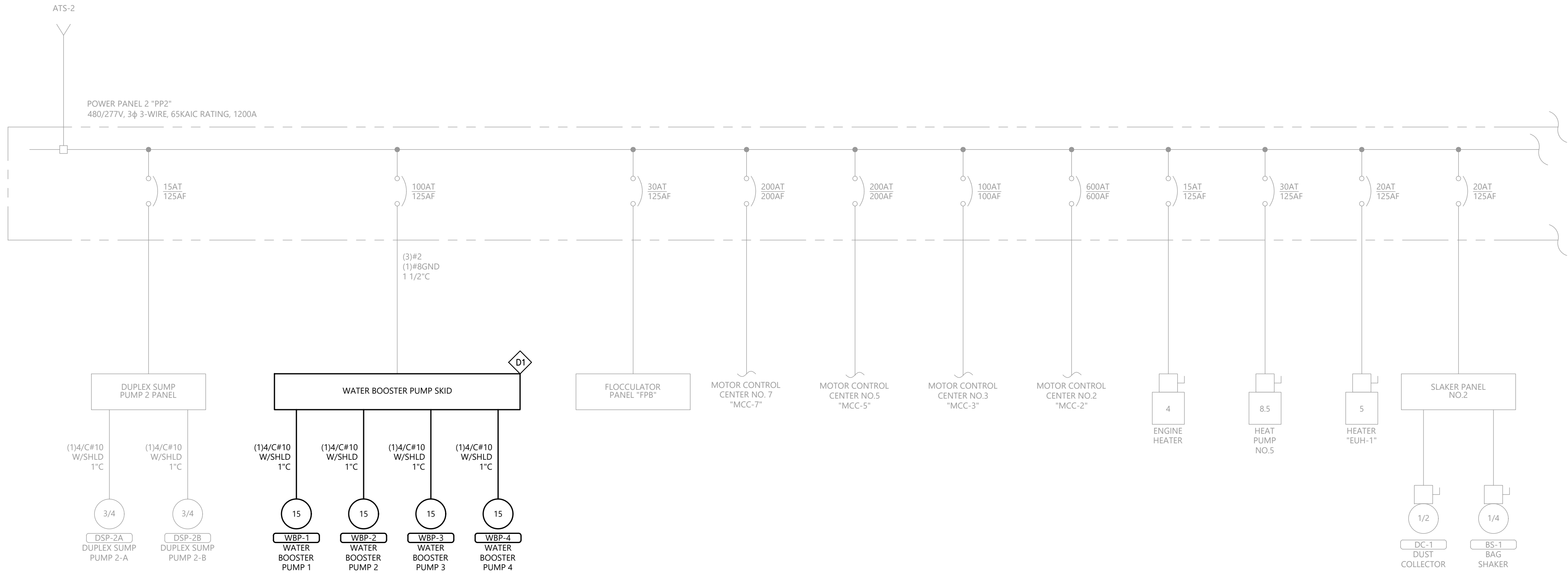
DRAWING NO:

**M.2-01-101**



\\woodardcurran.net\shared\Projects\0234978.01 Water Booster System Improvements\wip\Drawings\Electrical\E-0-001.dwg, Aug 27, 2026 - 11:14am WWEBBER

\\woodardcurran.net\shared\Projects\0234978.01 Water Booster System Improvements\wp\Drawings\Electrical\ED-0-010.dwg, Aug 27, 2025 - 11:15am, VVWEBBER



#### SHEET GENERAL NOTES

- COORDINATE ALL WORK SHOWN THIS SHEET WITH OTHER DISCIPLINES.
- ALL ITEMS SHOWN WITH LIGHT DESIGNATION INDICATE EXISTING EQUIPMENT TO REMAIN. ALL ITEMS SHOWN WITH BOLD DESIGNATION INDICATE EQUIPMENT TO BE DEMOLISHED.
- UNLESS INDICATED ON THIS SHEET, REFER TO VENDOR DOCUMENTATION FOR FINAL LOCATION OF EQUIPMENT PANELS, DISCONNECTS, CIRCUIT BREAKERS AND FINAL TERMINATION POINTS.



#### DEMOLITION KEYNOTES

- WATER BOOSTER SKID AND ASSOCIATED APPURTENANCES TO BE DISCONNECTED AND REMOVED. FEEDER CABLE AND CONDUIT TO BE PROTECTED FROM DAMAGE, AND REMAIN FOR RECONNECTION TO NEW EQUIPMENT.



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POTABLE WATER BOOSTER  
PUMP REPLACEMENT

| REV | MM/DD/YY | DESCRIPTION |
|-----|----------|-------------|
|-----|----------|-------------|

JOB NO: 0234978.01

DATE: AUGUST 2026

SCALE: N/A

DESIGNED BY: ZMP

DRAWN BY: DAS

CHECKED BY: AJF

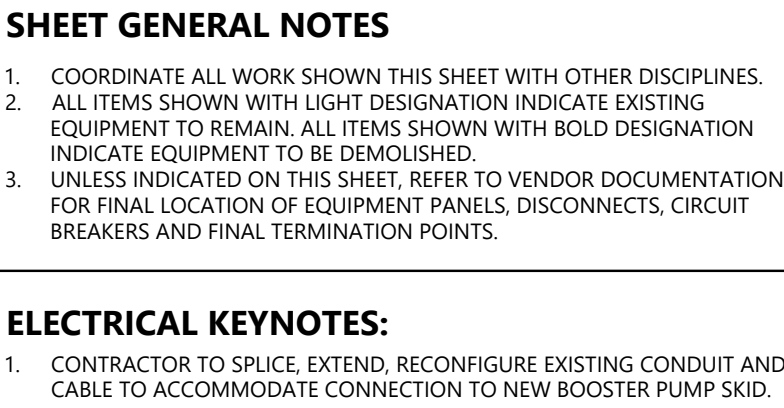
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DRAWING TITLE:

**ELECTRICAL  
DEMOLITION ONE-LINE  
DIAGRAM**

DRAWING NO:

**ED-0-010**



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**DRAWING TITLE:**  
**ELECTRICAL**  
**PROPOSED ONE-LINE DIAGRAM**

DRAWING NO:  
**E-0-010**