

ARLINGTON COUNTY, VIRGINIA
WATER POLLUTION CONTROL PLANT

ARLINGTON, VIRGINIA

BIDDING REQUIREMENTS
AND
CONTRACT DOCUMENTS

for the construction of the

FRP HYPO TANK REPLACEMENT

100% Specifications - Volume 1

JACOBS

Herndon, VA

March 2023

Project No. E5X6963B

Copy No. _____

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DRAWINGS (BOUND SEPARATELY)

END OF SECTION

SPECIFICATIONS

**SECTION 01 11 00
SUMMARY OF WORK**

PART 1 GENERAL

1.01 WORK COVERED BY CONTRACT DOCUMENTS

A. The completed Work will provide Owner with new equipment at the North Ferric Facility (NFF) and the Sodium Hypochlorite Facility (SHF) at the Arlington County Water Pollution Control Plant. The Work generally includes the following major elements:

1. North Ferric Facility:
 - a. Replacement of existing sodium hypochlorite FRP storage tank and associated piping, level elements, access ladder, and guardrail.
 - b. Modification to the existing sodium hypochlorite storage tank concrete pad.
 - c. Replacement of existing sodium hypochlorite containment sump pump and associated control panel.
 - 1) The Work at the North Ferric Facility includes the following constraints:
 - a) The Owner requires that the sodium hypochlorite metering pumps are available for service continuously during construction. The Contractor can request the Owner for one outage up to a maximum of three days to relocate the sodium hypochlorite chemical totes that feed the metering pumps.
2. Sodium Hypochlorite Facility:
 - a. Replacement of four existing sodium hypochlorite FRP storage tanks and associated piping, valves, level elements, access ladders, and guardrail.
 - 1) The Work at the Sodium Hypochlorite Facility includes the following constraints:
 - a) The Owner requires that at least two sodium hypochlorite chemical storage tanks are available for service continuously during construction.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION (NOT USED)

END OF SECTION

SECTION 01 31 19
PROJECT MEETINGS

PART 1 GENERAL

1.01 GENERAL

- A. Engineer or Owner's representative will schedule physical arrangements for meetings throughout progress of the Work, prepare meeting agenda with regular participant input and distribute with written notice of each meeting, preside at meetings, record minutes to include significant proceedings and decisions, and reproduce and distribute copies of minutes within 5 days after each meeting to participants and parties affected by meeting decisions.

1.02 PRECONSTRUCTION MEETING

- A. Contractor shall be prepared to discuss the following subjects, as a minimum:

1. Required schedules.
2. Status of Bonds and insurance.
3. Sequencing of critical path work items.
4. Progress payment procedures.
5. Project changes and clarification procedures.
6. Submittal procedures and planned initial critical submittals.
7. Use of Site, access, office and storage areas, security and temporary facilities.
8. Major product delivery and priorities.
9. Contractor's safety plan and representative.

- B. Attendees will include:

1. Owner's representatives.
2. Contractor's office representative.
3. Contractor's resident superintendent.
4. Contractor's quality control representative.
5. Subcontractors' representatives whom Contractor may desire or Engineer may request to attend.
6. Engineer's representatives.
7. Others as appropriate.

1.03 PROGRESS MEETINGS

- A. Engineer will schedule regular progress meetings at Site, conducted bi-weekly, to review the Work progress, Progress Schedule, Schedule of Submittals, clarification requests, Application for Payment, contract

modifications and change items, and other matters needing discussion and resolution.

1. Contractor shall prepare a 30-day look ahead schedule noting key anticipated events for discussion at progress meeting.

B. Attendees will include:

1. Owner's representative(s), as appropriate.
2. Contractor, Subcontractors, and Suppliers, as appropriate.
3. Engineer's representative(s).
4. Others as appropriate.

1.04 PREINSTALLATION MEETINGS

- A. When required in individual Specification sections, convene at Site prior to commencing the Work of that section.
- B. Require attendance of entities directly affecting, or affected by, the Work of that section.
- C. Notify Engineer five days in advance of meeting date.
- D. Provide suggested agenda to Engineer to include reviewing conditions of installation, preparation and installation or application procedures, and coordination with related Work and work of others.
- E. The Contractor shall lead and conduct the preinstallation meetings.

1.05 OTHER MEETINGS

- A. In accordance with Contract Documents and as may be required by Owner and Engineer.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION (NOT USED)

END OF SECTION

SECTION 01 33 00
SUBMITTAL PROCEDURES

PART 1 GENERAL

1.01 DEFINITIONS

- A. Action Submittal: Written and graphic information submitted by Contractor that requires Engineer's approval.
- B. Informational Submittal: Information submitted by Contractor that requires Engineer's review and determination that submitted information is in accordance with the Conditions of the Contract.

1.02 PROCEDURES

- A. Direct submittals to the Owner/Engineer for review and approval.
- B. Electronic Submittals: Submittals shall be made in electronic format via e-Builder.
 - 1. Each submittal shall be an electronic file in Adobe Acrobat Portable Document Format (PDF). Use the latest version available at time of execution of the Agreement.
 - 2. Electronic files that contain more than 10 pages in PDF format shall contain internal bookmarking from an index page to major sections of the document.
 - 3. PDF files shall be set to open "Bookmarks and Page" view.
 - 4. Add general information to each PDF file, including title, subject, author, and keywords.
 - 5. PDF files shall be set up to print legibly at 8.5-inch by 11-inch, 11-inch by 17-inch, or 22-inch by 34-inch. No other paper sizes will be accepted.
 - 6. Submit new electronic files for each resubmittal.
 - 7. Include a copy of the Transmittal of Contractor's Submittal form, located at end of section, with each electronic file.
 - 8. Provide Engineer with authorization to reproduce and distribute each file as many times as necessary for Project documentation.
 - 9. Detailed procedures for handling electronic submittals will be discussed at the preconstruction conference.

C. Transmittal of Submittal:

1. Contractor shall:
 - a. Review each submittal and check for compliance with Contract Documents.
 - b. Stamp each submittal with uniform approval stamp as included in the General Provisions before submitting to Engineer.
 - 1) Engineer will not review submittals that do not bear Contractor's approval stamp and will return them without action.
2. Complete, sign, and transmit with each submittal package, one Transmittal of Contractor's Submittal form attached at end of this section.
3. Identify each submittal with the following:
 - a. Numbering and Tracking System:
 - 1) Sequentially number each submittal, per each Specification section (e.g., XX XX XX – 01).
 - 2) Resubmission of submittal shall have original number with sequential alphabetic suffix (e.g., XX XX XX – 01A).
 - a) Resubmission of submittals (i.e., resubmittals) shall include responses to the Engineer's previous submittal review comments indicating that comments were acknowledged and explaining how they were addressed. This information shall be included at the beginning of the resubmittal.
 - b. Specification section and paragraph to which submittal applies.
 - c. Project title.
 - d. Date of transmittal.
 - e. Names of Contractor, Subcontractor or Supplier, and manufacturer as appropriate.
4. Identify and describe each deviation or variation from Contract Documents.

D. Format:

1. Do not base Shop Drawings on reproductions of Contract Documents.
2. Package submittal information by individual specification section. Do not combine different specification sections together in submittal package, unless otherwise directed in specification.
3. Present in a clear and thorough manner and in sufficient detail to show kind, size, arrangement, and function of components, materials, and devices, and compliance with Contract Documents.
4. Index with labeled tab dividers in orderly manner.

- E. Timeliness: Schedule and submit in accordance Schedule of Submittals, and requirements of individual specification sections.

- F. Processing Time:
1. Time for review shall commence on Engineer's receipt of submittal.
 2. Engineer will act upon Contractor's submittal and transmit response to Contractor not later than 30 days after receipt, unless otherwise specified.
 3. Resubmittals will be subject to same review time.
 4. No adjustment of Contract Times or Price will be allowed as a result of delays in progress of Work caused by rejection and subsequent resubmittals.
- G. Resubmittals: Clearly identify each correction or change made. List the Engineer's review comments from the previous submittal cycle and provide direct responses describing how each review comment was addressed.
- H. Incomplete Submittals:
1. Engineer will return entire submittal for Contractor's revision if preliminary review deems it incomplete.
 2. When any of the following are missing, submittal will be deemed incomplete:
 - a. Contractor's review stamp; completed and signed.
 - b. Transmittal of Contractor's Submittal; completed and signed.
- I. Submittals not required by Contract Documents:
1. Will not be reviewed and will be returned stamped "Not Subject to Review."
 2. Engineer will keep one copy and return submittal to Contractor.

1.03 ACTION SUBMITTALS

- A. Prepare and submit Action Submittals required by individual specification sections.
- B. Shop Drawings:
1. Identify and Indicate:
 - a. Applicable Contract Drawing and Detail number, products, units and assemblies, and system or equipment identification or tag numbers.
 - b. Equipment and Component Title: Identical to title shown on Drawings.
 - c. Critical field dimensions and relationships to other critical features of Work. Note dimensions established by field measurement.
 - d. Project-specific information drawn accurately to scale.

2. Manufacturer's standard schematic drawings and diagrams as follows:
 - a. Modify to delete information that is not applicable to the Work.
 - b. Supplement standard information to provide information specifically applicable to the Work.
 3. Product Data: Provide as specified in individual specifications.
- C. Samples:
1. Copies: Two, unless otherwise specified in individual specifications.
 2. Preparation: Mount, display, or package Samples in manner specified to facilitate review of quality. Attach label on unexposed side that includes the following:
 - a. Manufacturer name.
 - b. Model number.
 - c. Material.
 - d. Sample source.
 3. Manufacturer's Color Chart: Units or sections of units showing full range of colors, textures, and patterns available.
 4. Full-size Samples:
 - a. Size as indicated in individual specification section.
 - b. Prepared from same materials to be used for the Work.
 - c. Cured and finished in manner specified.
 - d. Physically identical with product proposed for use.
- D. Submittal Action Codes: Engineer will review, comment, and distribute as noted.
1. Accepted:
 - a. Contractor may incorporate product(s) or implement Work covered by submittal.
 - b. Distribution: Electronic, appropriately annotated.
 2. Accepted as Noted:
 - a. Contractor may incorporate product(s) or implement Work covered by submittal, in accordance with Engineer's notations.
 - b. Distribution: Electronic, appropriately annotated.
 3. Revise and Resubmit:
 - a. Make corrections or obtain missing portions, and resubmit the entire revised submittal package.
 - b. Contractor may not incorporate product(s) or implement Work covered by submittal.
 - c. Distribution: Electronic, appropriately annotated.
 4. Rejected:
 - a. Contractor may not incorporate product(s) or implement Work covered by submittal.
 - b. Distribution: Electronic, appropriately annotated.
- E. Action Submittals shall be submitted in advance of the need for the material or equipment for construction. Contractor shall assume the risk for all materials or equipment that are fabricated or delivered prior to submittal

approval. Materials or equipment shall not be included in periodic Progress Payments until the required Action Submittals have been approved by the Engineer.

F. “Or-Equal” Products:

1. Where permitted in the Project Specifications, Contractor may propose an alternate “or-equal” product for Engineer’s approval.
2. “Or-equal” products shall, in the judgment of the Engineer:
 - a. Be at least equal in materials of construction, quality, durability, appearance, strength and design characteristics.
 - b. Reliably perform equally well the function of the design concept.
 - c. Have a proven record of performance and availability of responsive service.
3. “Or-equal” products shall not increase Project cost or contract times.

1.04 INFORMATIONAL SUBMITTALS

A. General:

1. Refer to individual specification sections for specific submittal requirements.
2. Engineer will review each submittal. If submittal meets conditions of the Contract, Engineer will distribute electronic copy to appropriate parties. If Engineer determines submittal does not meet conditions of the Contract and is therefore considered unacceptable, Engineer will return with review comments to Contractor, and require that submittal be corrected and resubmitted.

B. Certificates:

1. General:
 - a. Provide notarized statement that includes signature of entity responsible for preparing certification.
 - b. Signed by officer or other individual authorized to sign documents on behalf of that entity.
2. Installer: Prepare written statements on manufacturer’s letterhead certifying installer complies with requirements as specified in individual specification section.
3. Material Test: Prepared by qualified testing agency, on testing agency’s standard form, indicating and interpreting test results of material for compliance with requirements.
4. Certificates of Successful Testing or Inspection: Submit when testing or inspection is required by Laws and Regulations or governing agency or specified in individual specification sections.
5. Manufacturer’s Certificate of Compliance: In accordance with Section 01 61 00, Common Product Requirements.

6. Manufacturer's Certificate of Proper Installation: In accordance with Section 01 43 33, Manufacturers' Field Services.
- C. Closeout Submittals: In accordance with Section 01 77 00, Closeout Procedures.
- D. Manufacturer's Instructions: Written or published information that documents manufacturer's recommendations, guidelines, and procedures in accordance with individual specification section.
- E. Operation and Maintenance Data: As required in Section 01 78 23, Operation and Maintenance Manuals.
- F. Special Guarantee: Supplier's written guarantee as required in individual specification sections.
- G. Test, Evaluation, and Inspection Reports:
 1. General: Shall contain signature of person responsible for test or report.
 2. Factory:
 - a. Identification of product and specification section, type of inspection or test with referenced standard or code.
 - b. Date of test, Project title and number, and name and signature of authorized person.
 - c. Test results.
 - d. If test or inspection deems material or equipment not in compliance with Contract Documents, identify corrective action necessary to bring into compliance.
 - e. Provide interpretation of test results, when requested by Engineer.
 - f. Other items as identified in individual specification sections.
 3. Field:
 - a. As a minimum, include the following:
 - 1) Project title and number.
 - 2) Date and time.
 - 3) Record of temperature and weather conditions.
 - 4) Identification of product and specification section.
 - 5) Type and location of test, Sample, or inspection, including referenced standard or code.
 - 6) Date issued, testing laboratory name, address, and telephone number, and name and signature of laboratory inspector.
 - 7) If test or inspection deems material or equipment not in compliance with Contract Documents, identify corrective action necessary to bring into compliance.
 - 8) Provide interpretation of test results, when requested by Engineer.
 - 9) Other items as identified in individual specification sections.
- H. Testing and Startup Data: In accordance with Section 01 91 14, Equipment Testing and Facility Startup.

- I. Training Data: In accordance with Section 01 43 33, Manufacturers' Field Services.

1.05 SUPPLEMENTS

- A. The supplement listed below, following "End of Section," is part of this specification.
 1. Transmittal of Contractor's Submittal Form.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION (NOT USED)

END OF SECTION



CONTRACTOR SUBMITTAL COVER SHEET

ARLINGTON COUNTY WATER POLLUTION CONTROL BUREAU
FRP Hypo Tank Replacement

| | | | | | | | | |
|--------------|--|---|--------------|--------------|------|--|--|--|
| To: | Submittal Type <input type="checkbox"/> Plans <input type="checkbox"/> Procedures <input type="checkbox"/> Shop Drawings <input type="checkbox"/> Supplier's Data <input type="checkbox"/> Samples <input type="checkbox"/> Other: _____ | Submittal No. <table style="width: 100%; border-collapse: collapse;"> <tr> <td style="text-align: center; font-size: small;">Spec Section</td> <td style="text-align: center; font-size: small;">Sequence No.</td> <td style="text-align: center; font-size: small;">Rev.</td> </tr> <tr> <td style="border: 1px solid black; width: 20px; height: 20px;"></td> <td style="border: 1px solid black; width: 20px; height: 20px;"></td> <td style="border: 1px solid black; width: 20px; height: 20px;"></td> </tr> </table> Example: 012345-001-A Submittal Name – Additional Information | Spec Section | Sequence No. | Rev. | | | |
| Spec Section | Sequence No. | Rev. | | | | | | |
| | | | | | | | | |
| From: | Contract No. | Contractor Job No. | | | | | | |
| | Date Submitted: | Component Tag No. | | | | | | |

| ITEM No. | No. of Copies | DESCRIPTION (Use a separate cover sheet for each submittal) | Reviewer Action Code |
|----------|---------------|--|----------------------|
| | | | Choose an item. |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |

Items are transmitted as checked below:

For information only
 For review & comment
 Other: _____

Contractor's Remark/Comments Enter Comments Here

Signed: _____

Additional comment sheet attached

Title: _____

Rec'd By: Enter Name Date: Sent To: Date:

Rec'd By: Enter Name Date: Sent To: Date:

- a) Work shall proceed only when action code is Approved or Approved as Noted.
- b) Action code Revise and Resubmit shall be resubmitted within time limit set in contract.
- c) Review does not relieve Contractor from responsibility of compliance with all requirements of the Contract Documents.

SUBMITTAL REVIEW

Returned By: _____

Company: _____

Date Returned: _____

SECTION 01 43 33
MANUFACTURERS' FIELD SERVICES

PART 1 GENERAL

1.01 DEFINITIONS

- A. Person-Day: One person for eight hours within regular Contractor working hours.

1.02 QUALIFICATION OF MANUFACTURER'S REPRESENTATIVE

- A. Authorized representative of the manufacturer, factory trained, and experienced in the technical applications, installation, operation, and maintenance of respective equipment, subsystem, or system, with full authority by the equipment manufacturer to issue the certifications required of the manufacturer. Additional qualifications may be specified in the individual specification section.
- B. Representative subject to acceptance by Owner and Engineer. No substitute representatives will be allowed unless prior written approval by such has been given.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.01 FULFILLMENT OF SPECIFIED MINIMUM SERVICES

- A. Furnish manufacturers' services as required by this section or an individual specification section.
- B. Where time is necessary in excess of that stated in the Specifications for manufacturers' services, or when a minimum time is not specified, time required to perform specified services shall be considered incidental.
- C. Schedule manufacturers' services to avoid conflict with other onsite testing or other manufacturers' onsite services.
- D. Determine, before scheduling services, that conditions necessary to allow successful testing have been met.
- E. Only those days of service approved by Engineer will be credited to fulfill specified minimum services.

- F. When specified in individual specification sections, manufacturer's onsite services shall include:
1. Assistance during product (system, subsystem, or component) installation to include observation, guidance, instruction of Contractor's assembly, erection, installation or application procedures.
 2. Inspection, checking, and adjustment as required for product (system, subsystem, or component) to function as warranted by manufacturer and necessary to furnish Manufacturer's Certificate of Proper Installation.
 3. Providing, on a daily basis, copies of manufacturers' representatives field notes and data to Engineer.
 4. Revisiting the Site as required to correct problems and until installation and operation are acceptable to Engineer.
 5. Resolution of assembly or installation problems attributable to or associated with respective manufacturer's products and systems.
 6. Assistance during functional and performance testing, and facility startup and evaluation.
 7. Training of Owner's personnel in the operation and maintenance of respective product as required.

3.02 MANUFACTURER'S CERTIFICATE OF PROPER INSTALLATION

- A. When so specified, a Manufacturer's Certificate of Proper Installation form, a copy of which is attached to this section, shall be completed and signed by equipment manufacturer's representative.
- B. Such form shall certify signing party is a duly authorized representative of manufacturer, is empowered by manufacturer to inspect, approve, and operate their equipment and is authorized to make recommendations required to ensure equipment is complete and operational.

3.03 TRAINING

- A. General:
1. Furnish manufacturers' representatives for detailed classroom and hands-on training to Owner's personnel on operation and maintenance of specified product (system, subsystem, component) and as may be required in applicable Specifications.
 2. Furnish trained, articulate personnel to coordinate and expedite training, to be present during training coordination meetings with Owner, and familiar with operation and maintenance manual information specified in Section 01 78 23, Operation and Maintenance Manuals.
 3. Manufacturer's representative shall be familiar with facility operation and maintenance requirements as well as with specified equipment.
 4. Furnish complete training materials, to include operation and maintenance data, to be retained by each trainee.

B. Training Schedule:

1. Provide training for the following equipment:
 - a. Submersible Sump Pumps specified in Section 22 30 00, Submersible Sump Pumps.
 - b. Electric Motor Actuators specified in Section 40 27 02, Process Valves and Operators.
 - c. L007E Level Element and Transmitter, Radar, Type E specified in Section 40 90 01.01, Components Specifications.
 - d. L10 Level Transmitter, Direct Sensing, Flange Mounted specified in Section 40 90 01.01, Components Specifications.
2. List specified equipment and systems that require training services and show:
 - a. Respective manufacturer.
 - b. Estimated dates for installation completion.
 - c. Estimated training dates.
3. Provide at least two training sessions.
4. Adjust schedule to ensure training of appropriate personnel as deemed necessary by Owner, and to allow full participation by manufacturers' representatives. Adjust schedule for interruptions in operability of equipment.
5. Coordinate with submission of operation and maintenance manuals in accordance with Section 01 78 23, Operation and Maintenance Manuals.

3.04 SUPPLEMENTS

- A. The supplements listed below, following "End of Section," are part of this Specification.
1. Form: Manufacturer's Certificate of Proper Installation.

END OF SECTION

MANUFACTURER'S CERTIFICATE OF PROPER INSTALLATION

OWNER _____ EQPT SERIAL NO: _____
EQPT TAG NO: _____ EQPT/SYSTEM: _____
PROJECT NO: _____ SPEC. SECTION: _____

I hereby certify that the above-referenced equipment/system has been:

(Check Applicable)

- Installed in accordance with Manufacturer's recommendations.
- Inspected, checked, and adjusted.
- Serviced with proper initial lubricants.
- Electrical and mechanical connections meet quality and safety standards.
- All applicable safety equipment has been properly installed.
- Functional tests.
- System has been performance tested, and meets or exceeds specified performance requirements. (When complete system of one manufacturer)

Note: Attach any performance test documentation from manufacturer.

Comments: _____

I, the undersigned Manufacturer's Representative, hereby certify that I am (i) a duly authorized representative of the manufacturer, (ii) empowered by the manufacturer to inspect, approve, and operate their equipment and (iii) authorized to make recommendations required to ensure equipment furnished by the manufacturer is complete and operational, except as may be otherwise indicated herein. I further certify that all information contained herein is true and accurate.

Date: _____, 20_____

Manufacturer: _____

By Manufacturer's Authorized Representative: _____

(Authorized Signature)

SECTION 01 50 00
TEMPORARY FACILITIES AND CONTROLS

PART 1 GENERAL

1.01 SUBMITTALS

A. Informational Submittals:

1. Copies of permits and approvals for construction as required by Laws and Regulations and governing agencies.
2. Temporary Construction Submittals: Plans showing Contractor field offices, parking, and staging and storage areas, including any gravel surfaced areas. Indicate proposed temporary utility connections.

1.02 MOBILIZATION

A. Mobilization shall include, but not be limited to, these principal items:

1. Obtaining required permits.
2. Moving Contractor's field office and equipment required for initial operations onto Site.
3. Installing temporary construction power, wiring, and lighting facilities.
4. Providing onsite sanitary facilities.
5. Arranging for, and erection of, Contractor's work and storage yard.
6. Posting OSHA required notices and establishing safety programs and procedures.

1.03 PROTECTION OF WORK AND PROPERTY

- A. Comply with Owner's safety rules while on Owner's property.
- B. Keep Owner informed of all work related accidents and related claims.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.01 TEMPORARY UTILITIES

- A. Power: Electric power will be available at or near Site. Determine type and amount available and make arrangements for obtaining temporary electrical power service, as required.
- B. Lighting: Provide temporary lighting to meet applicable safety requirements to allow erection, application, or installation of materials and equipment, and observation or inspection of the Work.

C. Heating, Cooling, and Ventilating:

1. Provide as required to maintain adequate environmental conditions to facilitate progress of the Work, to meet specified minimum conditions for installation of materials, and to protect materials, equipment, and finishes from damage because of temperature or humidity.
2. Provide adequate forced air ventilation of enclosed areas to cure installed materials, to dispense humidity, and to prevent hazardous accumulations of dust, fumes, vapors, or gases.
3. Pay costs of installation, maintenance, operation, removal, and fuel consumed.
4. Provide portable unit heaters, complete with controls, oil- or gas-fired, and suitably vented to outside as required for protection of health and property.

D. Water:

1. Owner will furnish water required for construction activities at no cost to Contractor on Site. Furnish and install temporary piping and facilities to transport water to the Work.
2. Provide means to prevent water used for testing from flowing back into source pipeline.

E. Sanitary and Personnel Facilities:

1. Provide and maintain facilities for Contractor's employees, Subcontractors, and other onsite employers' employees. Service, clean, and maintain facilities and enclosures.
2. Use of Owner's existing sanitary facilities by construction personnel will not be allowed.

F. Fire Protection: Furnish and maintain on Site adequate firefighting equipment capable of extinguishing incipient fires. Comply with applicable parts of NFPA 241.

3.02 PROTECTION OF WORK AND PROPERTY

A. General:

1. Maintain in continuous service existing underground power, telephone or communication cable, water mains, irrigation lines, sewers, poles and overhead power, and other utilities encountered along line of the Work, unless other arrangements satisfactory to owners of said utilities have been made.
2. Where completion of the Work requires temporary or permanent removal or relocation of existing utility, coordinate activities with owner of said utility and perform work to their satisfaction.

3. Protect, shore, brace, support, and maintain underground pipes, conduits, drains, and other underground utility construction uncovered or otherwise affected by construction operations.
4. Keep fire hydrants and water control valves free from obstruction and available for use at all times.
5. In areas where Contractor's operations are adjacent to or near a utility, such as telephone or communication, electric power, water, sewer, or irrigation system, and such operations may cause damage or inconvenience, suspend operations until arrangements necessary for protection have been made by Contractor.
6. Notify property owners and utility offices that may be affected by construction operation at least 2 days in advance: Before exposing a utility, obtain utility owner's permission. Should service of utility be interrupted due to Contractor's operation, notify proper authority immediately. Cooperate with said authority in restoring service as promptly as possible and bear costs incurred.
7. Maintain original Site drainage wherever possible.

B. Site Security:

1. Provide and maintain additional temporary security fences as necessary to protect the Work and Contractor-furnished products not yet installed.
2. Access to the Site:
 - a. Coordinate site access procedures with Owner and Engineer at the preconstruction conference.
 - b. Contractor shall provide a designated person for monitoring and directing construction-related personnel and traffic during normal working hours. Provide Owner and Engineer advanced notice of large equipment and material deliveries.
 - c. Contractor shall issue personnel ID badges that shall be worn at all times when personnel are on Site. Contractor shall also maintain an updated list of all personnel working on Site.
 - d. Only marked construction vehicles will be permitted on Site. No private vehicles are allowed.
 - e. Immediately notify Owner and Engineer of any suspicious activity noted around or near the Site.

C. Barricades and Lights:

1. Provide as necessary to prevent unauthorized entry to construction areas and affected roads inside and outside of fenced area, and as required to ensure public safety and the safety of Contractor's employees, other employer's employees, and others who may be affected by the Work.
2. Provide to protect existing facilities from potential damage.
3. Locate to enable access by facility operators and property owners.

4. Protect roads that are closed to traffic by effective barricades with acceptable warning signs.
 5. Illuminate barricades and obstructions with warning lights from sunset to sunrise.
- D. Finished Construction: Protect finished floors and concrete floors exposed as well as those covered with composition tile or other applied surfacing.
- E. Waterways: Keep ditches, culverts, and natural drainages continuously free of construction materials and debris.

3.03 TEMPORARY CONTROLS

A. Air Pollution Control:

1. Minimize air pollution from construction operations.
2. Burning of waste materials, rubbish, or other debris will not be permitted on or adjacent to Site.
3. Conduct operations of dumping rock and of carrying rock away in trucks to cause a minimum of dust. Give unpaved streets, roads, detours, or haul roads used in construction area a dust-preventive treatment or periodically water to prevent dust. Strictly adhere to applicable environmental regulations for dust prevention.
4. Provide and maintain temporary dust-tight partitions, bulkheads, or other protective devices during construction to permit normal operation of existing facilities. Construct partitions of plywood, insulating board, plastic sheets, or similar material. Construct partitions in such a manner that dust and dirt from demolition and cutting will not enter other parts of existing building or facilities. Remove temporary partitions as soon as need no longer exists.

B. Noise Control: Provide acoustical barriers so noise emanating from tools or equipment will not exceed legal noise levels.

C. Water Pollution Control:

1. Comply with requirements of Erosion and Sediment Control Plan Drawings.
2. Do not dispose of volatile wastes such as mineral spirits, oil, chemicals, or paint thinner in storm or sanitary drains. Disposal of wastes into streams or waterways is prohibited. Provide acceptable containers for collection and disposal of waste materials, debris, and rubbish.

D. Erosion, Sediment, and Flood Control: Provide, maintain, and operate temporary facilities as required to control erosion and sediment releases, and to protect the Work and existing facilities from flooding during construction period.

3.04 STORAGE YARDS AND BUILDINGS

- A. Temporary Storage Yards: Construct temporary storage yards for storage of products that are not subject to damage by weather conditions.
- B. Temporary Storage Buildings:
 - 1. Provide environmental control systems that meet recommendations of manufacturers of equipment and materials stored.
 - 2. Arrange or partition to provide security of contents and ready access for inspection and inventory.
 - 3. Store combustible materials (paints, solvents, fuels) in a well ventilated and remote building meeting safety standards.

3.05 CLEANING DURING CONSTRUCTION

- A. Wet down exterior surfaces prior to sweeping to prevent blowing of dust and debris. At least weekly, sweep all floors in work areas and pick up and dispose of debris.
- B. Provide approved containers for collection and disposal of waste materials, debris, and rubbish. At least weekly, dispose of such waste materials, debris, and rubbish offsite.
- C. At least weekly, brush sweep entry drive, roadways, and other streets affected by the Work and where adjacent to the Work.

END OF SECTION

SECTION 01 57 13
TEMPORARY EROSION AND SEDIMENT CONTROL

PART 1 GENERAL

1.01 SUMMARY OF WORK

- A. This section covers Work necessary for stabilization of soil to prevent erosion during construction and land disturbing activities. The minimum areas requiring soil erosion and sediment control measures are indicated on the Drawings. Engineer reserves the right to modify use, location, and quantities of soil erosion and sediment control measures based on activities of Contractor.

1.02 SYSTEM DESCRIPTION

- A. Erosion, Sediment, and Flood Control: Provide, maintain, and operate temporary facilities to control erosion and sediment releases, and to protect the Work and existing facilities from flooding during construction period.
- B. Soil erosion stabilization and sedimentation control consists of the following elements:
1. Construction and maintenance of permanent and temporary storm drainage piping and channel systems, as necessary.
 2. Construction of temporary erosion control facilities, such as silt fences and storm drain inlet protection.
 3. Placement and maintenance of temporary seeding on areas disturbed by construction.
- C. Activities shall conform to the Virginia Erosion and Sediment Control Handbook (VESCH), latest version, and Arlington County erosion control standards.
- D. The sections of the VESCH standards referenced above include, but are not limited to:

| Standard and Spec. No. | Symbol | Title |
|-------------------------------|---------------|------------------------------|
| 3.05 | SF | Silt Fence |
| 3.07 | IP | Storm Drain Inlet Protection |
| 3.30 | TO | Topsoiling |
| 3.32 | PS | Permanent Seeding |

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.01 PREPARATION

- A. Contractor shall be responsible for phasing Work in areas allocated for their exclusive use during Project, including installation of temporary erosion control devices, ditches, or other facilities.
- B. Areas set aside for Contractor's use during Project may be temporarily developed to provide satisfactory working, staging, and administrative areas. Preparation of these areas shall be in accordance with other requirements contained within Specifications and completed in a manner to control sediment transport away from area.

3.02 FIELD QUALITY CONTROL

- A. Conduct inspections jointly with Engineer every 2 weeks, and after every significant storm event.
- B. Replace or repair failed or overloaded silt fences, check dams, or other temporary erosion control devices within 2 days after Site inspections.

3.03 MAINTENANCE

- A. Promptly repair or replace erosion control measures that become damaged.
- B. Provide and maintain soil stabilization seeding at all times.
- C. Silt Trapping Measures:
 - 1. Clean measures of collected sediment after every storm or as determined from biweekly inspections.
 - 2. Perform cleaning in a manner that will not direct sediment into storm drain piping system.
 - 3. Take removed sediment to area selected by Engineer where it can be cleaned of sticks and debris, then allowed to dry.
 - 4. Dispose of final sediment and debris offsite.
- D. Inspect, repair, and replace as necessary erosion control measures during the time period from start of construction to completion of construction.

END OF SECTION

**SECTION 01 61 00
COMMON PRODUCT REQUIREMENTS**

PART 1 GENERAL

1.01 DEFINITIONS

A. Products:

1. New items for incorporation in the Work, whether purchased by Contractor or Owner for the Project, or taken from previously purchased stock, and may also include existing materials or components required for reuse.
2. Includes the terms material, equipment, machinery, components, subsystem, system, hardware, software, and terms of similar intent and is not intended to change meaning of such other terms used in Contract Documents, as those terms are self-explanatory and have well recognized meanings in construction industry.
3. Items identified by manufacturer's product name, including make or model designation, indicated in manufacturer's published product literature, that is current as of the date of the Contract Documents.

1.02 ENVIRONMENTAL REQUIREMENTS

- A. Altitude: Provide materials and equipment suitable for installation and operation under rated conditions at 25 feet above sea level.
- B. Provide equipment and devices installed outdoors or in unheated enclosures capable of continuous operation within an ambient temperature range of 0 degrees F to 110 degrees F.

1.03 PREPARATION FOR SHIPMENT

- A. When practical, factory assemble products. Mark or tag separate parts and assemblies to facilitate field assembly. Cover machined and unpainted parts that may be damaged by the elements with strippable protective coating.
- B. Package products to facilitate handling and protect from damage during shipping, handling, and storage. Mark or tag outside of each package or crate to indicate its purchase order number, bill of lading number, contents by name, name of Project and Contractor, equipment number, and approximate weight. Include complete packing list and bill of materials with each shipment.

- C. Extra Materials, Special Tools, Test Equipment, and Expendables:
 - 1. Furnish as required by individual Specifications.
 - 2. Schedule:
 - a. Ensure that shipment and delivery occurs concurrent with shipment of associated equipment.
 - b. Transfer to Owner shall occur immediately subsequent to Contractor's acceptance of equipment from Supplier.
 - 3. Packaging and Shipment:
 - a. Package and ship extra materials and special tools to avoid damage during long term storage in original cartons insofar as possible, or in appropriately sized, hinged-cover, wood, plastic, or metal box.
 - b. Prominently displayed on each package, the following:
 - 1) Manufacturer's part nomenclature and number, consistent with Operation and Maintenance Manual identification system.
 - 2) Applicable equipment description.
 - 3) Quantity of parts in package.
 - 4) Equipment manufacturer.
 - 4. Deliver materials to Site.
 - 5. Notify Engineer upon arrival for transfer of materials.
 - 6. Replace extra materials and special tools found to be damaged or otherwise inoperable at time of transfer to Owner.
- D. Request a minimum 7-day advance notice of shipment from manufacturer.
- E. Factory Test Results: Reviewed and accepted by Engineer before product shipment as required in individual Specification sections.

1.04 DELIVERY AND INSPECTION

- A. Deliver products in accordance with accepted current Progress Schedule and coordinate to avoid conflict with the Work and conditions at Site.
- B. Deliver products in undamaged condition, in manufacturer's original container or packaging, with identifying labels intact and legible. Include on label, date of manufacture and shelf life, where applicable.
- C. Unload products in accordance with manufacturer's instructions for unloading or as specified. Record receipt of products at Site. Promptly inspect for completeness and evidence of damage during shipment.
- D. Remove damaged products from Site and expedite delivery of identical new undamaged products, and remedy incomplete or lost products to provide that specified, so as not to delay progress of the Work.

1.05 HANDLING, STORAGE, AND PROTECTION

- A. Handle and store products in accordance with manufacturer's written instructions and in a manner to prevent damage. Store in approved storage yards or sheds provided in accordance with Section 01 50 00, Temporary Facilities and Controls. Provide manufacturer's recommended maintenance during storage, installation, and until products are accepted for use by Owner.
- B. Manufacturer's instructions for material requiring special handling, storage, or protection shall be provided prior to delivery of material.
- C. Arrange storage in a manner to provide easy access for inspection. Make periodic inspections of stored products to ensure that products are maintained under specified conditions, and free from damage or deterioration. Keep running account of products in storage to facilitate inspection and to estimate progress payments for products delivered, but not installed in the Work.
- D. Store electrical, instrumentation, and control products, and equipment with bearings in weather-tight structures maintained above 60 degrees F. Protect electrical, instrumentation, and control products, and insulate against moisture, water, and dust damage. Connect and operate continuously space heaters furnished in electrical equipment.
- E. Store fabricated products above ground on blocking or skids, and prevent soiling or staining. Store loose granular materials in well-drained area on solid surface to prevent mixing with foreign matter. Cover products that are subject to deterioration with impervious sheet coverings; provide adequate ventilation to avoid condensation.
- F. Store finished products that are ready for installation in dry and well-ventilated areas. Do not subject to extreme changes in temperature or humidity.
- G. After installation, provide coverings to protect products from damage due to traffic and construction operations. Remove coverings when no longer needed.
- H. Hazardous Materials: Prevent contamination of personnel, storage area, and Site. Meet requirements of product specification, codes, and manufacturer's instructions.

PART 2 PRODUCTS

2.01 GENERAL

- A. Provide manufacturer's standard materials suitable for service conditions, unless otherwise specified in the individual Specifications.

- B. Where product specifications include a named manufacturer, with or without model number, and also include performance requirements, named manufacturer's products must meet the performance specifications.
- C. Like items of products furnished and installed in the Work shall be end products of one manufacturer and of the same series or family of models to achieve standardization for appearance, operation and maintenance, spare parts and replacement, manufacturer's services, and implement same or similar process instrumentation and control functions in same or similar manner.
- D. Do not use materials and equipment removed from existing premises, except as specifically permitted by Contract Documents.
- E. Provide interchangeable components of the same manufacturer, for similar components, unless otherwise specified.
- F. Equipment, Components, Systems, and Subsystems: Design and manufacture with due regard for health and safety of operation, maintenance, and accessibility, durability of parts, and shall comply with applicable OSHA, state, and local health and safety regulations.
- G. Regulatory Requirement: Coating materials shall meet federal, state, and local requirements limiting the emission of volatile organic compounds and for worker exposure.
- H. Safety Guards: Provide for all belt or chain drives, fan blades, couplings, or other moving or rotary parts. Cover rotating part on all sides. Design for easy installation and removal. Use 16-gauge or heavier; galvanized steel, aluminum coated steel, or galvanized or aluminum coated 1/2-inch mesh expanded steel. Provide galvanized steel accessories and supports, including bolts. For outdoors application, prevent entrance of rain and dripping water.
- I. Authority Having Jurisdiction (AHJ):
 - 1. Provide the Work in accordance with NFPA 70, National Electrical Code (NEC). Where required by the AHJ, material and equipment shall be labeled or listed by a nationally recognized testing laboratory or other organization acceptable to the AHJ in order to provide a basis for approval under NEC.
 - 2. Materials and equipment manufactured within the scope of standards published by Underwriters Laboratories, Inc. shall conform to those standards and shall have an applied UL listing mark.

- J. Equipment Finish:
 - 1. Provide manufacturer's standard finish and color, except where specific color is indicated.
 - 2. If manufacturer has no standard color, provide equipment with gray finish as approved by Engineer.

- K. Special Tools and Accessories: Furnish to Owner, upon acceptance of equipment, all accessories required to place each item of equipment in full operation. These accessory items include, but are not limited to, adequate oil and grease (as required for first lubrication of equipment after field testing), light bulbs, fuses, hydrant wrenches, valve keys, handwheels, chain operators, special tools, and other spare parts as required for maintenance.

- L. Lubricant: Provide initial lubricant recommended by equipment manufacturer in sufficient quantity to fill lubricant reservoirs and to replace consumption during testing, startup, and operation until final acceptance by Owner.

- M. Components and Materials in Contact with Water for Human Consumption: Comply with the requirements of the Safe Drinking Water Act and other applicable federal, state, and local requirements. Provide certification by manufacturer or an accredited certification organization recognized by the Authority Having Jurisdiction that components and materials comply with the maximum lead content standard in accordance with NSF/ANSI 61 and NSF/ANSI 372.
 - 1. Use or reuse of components and materials without a traceable certification is prohibited.

2.02 FABRICATION AND MANUFACTURE

- A. General:
 - 1. Manufacture parts to U.S.A. standard sizes and gauges.
 - 2. Two or more items of the same type shall be identical, by the same manufacturer, and interchangeable.
 - 3. Design structural members for anticipated shock and vibratory loads.
 - 4. Use 1/4-inch minimum thickness for steel that will be submerged, wholly or partially, during normal operation.
 - 5. Modify standard products as necessary to meet performance Specifications.

- B. Lubrication System:
 - 1. Require no more than weekly attention during continuous operation.
 - 2. Convenient and accessible; oil drains with bronze or stainless steel valves and fill-plugs easily accessible from the normal operating area or

platform. Locate drains to allow convenient collection of oil during oil changes without removing equipment from its installed position.

3. Provide constant-level oilers or oil level indicators for oil lubrication systems.
4. For grease type bearings, which are not easily accessible, provide and install stainless steel tubing; protect and extend tubing to convenient location with suitable grease fitting.

2.03 SOURCE QUALITY CONTROL

- A. Where Specifications call for factory testing to be witnessed by Engineer, notify Engineer not less than 14 days prior to scheduled test date, unless otherwise specified.
- B. Calibration Instruments: Bear the seal of a reputable laboratory certifying instrument has been calibrated within the previous 12 months to a standard endorsed by the National Institute of Standards and Technology (NIST).
- C. Factory Tests: Perform in accordance with accepted test procedures and document successful completion.

PART 3 EXECUTION

3.01 INSPECTION

- A. Inspect materials and equipment for signs of pitting, rust decay, or other deleterious effects of storage. Do not install material or equipment showing such effects. Remove damaged material or equipment from the Site and expedite delivery of identical new material or equipment. Delays to the Work resulting from material or equipment damage that necessitates procurement of new products will be considered delays within Contractor's control.

3.02 MANUFACTURER'S CERTIFICATE OF COMPLIANCE

- A. When so specified, a Manufacturer's Certificate of Compliance, a copy of which is attached to this section, shall be completed in full, signed by entity supplying the product, material, or service, and submitted prior to shipment of product or material or execution of the services.
- B. Engineer may permit use of certain materials or assemblies prior to sampling and testing if accompanied by accepted certification of compliance.
- C. Such form shall certify proposed product, material, or service complies with that specified. Attach supporting reference data, affidavits, and certifications as appropriate.
- D. May reflect recent or previous test results on material or product, if acceptable to Engineer.

3.03 INSTALLATION

- A. Equipment drawings and shop drawings show general locations of equipment, devices, and raceway, unless specifically dimensioned.
- B. No shimming between machined surfaces is allowed.
- C. Install the Work in accordance with NECA Standard of Installation, unless otherwise specified.
- D. Repaint painted surfaces that are damaged prior to equipment acceptance.
- E. Do not cut or notch any structural member or building surface without specific approval of Engineer.
- F. Handle, install, connect, clean, condition, and adjust products in accordance with manufacturer's instructions, and as may be specified. Retain a copy of manufacturers' instruction at Site, available for review at all times.
- G. For material and equipment specifically indicated or specified to be reused in the Work:
 - 1. Use special care in removal, handling, storage, and reinstallation to assure proper function in the completed Work.
 - 2. Arrange for transportation, storage, and handling of products that require offsite storage, restoration, or renovation. Include costs for such Work in the Contract Price.

3.04 FIELD FINISHING

- A. In accordance with Section 09 97 00 Special Coatings, and individual Specification sections.

3.05 ADJUSTMENT AND CLEANING

- A. Perform required adjustments, tests, operation checks, and other startup activities.

3.06 LUBRICANTS

- A. Fill lubricant reservoirs and replace consumption during testing, startup, and operation prior to acceptance of equipment by Owner.

3.07 SUPPLEMENTS

- A. The supplement listed below, following “End of Section,” is part of this specification.
1. Form: Manufacturer’s Certificate of Compliance.

END OF SECTION

MANUFACTURER'S CERTIFICATE OF COMPLIANCE

OWNER: _____ PRODUCT, MATERIAL, OR SERVICE
PROJECT NAME: _____ SUBMITTED: _____
PROJECT NO: _____

Comments: _____

I hereby certify that the above-referenced product, material, or service called for by the Contract for the named Project will be furnished in accordance with all applicable requirements. I further certify that the product, material, or service are of the quality specified and conform in all respects with the Contract requirements, and are in the quantity shown.

Date of Execution: _____, 20__

Manufacturer: _____

Manufacturer's Authorized Representative (*print*): _____

(Authorized Signature)

**SECTION 01 77 00
CLOSEOUT PROCEDURES**

PART 1 GENERAL

1.01 SUBMITTALS

A. Informational Submittals:

1. Submit prior to application for final payment.
 - a. Record Documents: As required in General Conditions and this Section.
 - b. Special bonds, Special Guarantees, and Service Agreements.
 - c. Consent of Surety to Final Payment: As required in General Provisions.
 - d. Releases or Waivers of Liens and Claims: As required in General Provisions.
 - e. Releases from Agreements.
 - f. Final Application for Payment: Submit in accordance with procedures and requirements stated in General Provisions.
 - g. Extra Materials: As required by individual Specification sections.

1.02 RECORD DOCUMENTS

A. Quality Assurance:

1. Provide qualified and experienced person, whose duty and responsibility shall be to maintain record documents.
2. Accuracy of Records:
 - a. Coordinate changes within record documents, making legible and accurate entries on each sheet of Drawings and other documents where such entry is required to show change.
 - b. Purpose of Project record documents is to document factual information regarding aspects of the Work, both concealed and visible, to enable future modification of the Work to proceed without lengthy and expensive Site measurement, investigation, and examination.
3. Make entries within 24 hours after receipt of information that a change in the Work has occurred.
4. Prior to submitting each request for progress payment, request Engineer's review and approval of current status of record documents. Failure to properly maintain, update, and submit record documents may result in a deferral by Engineer to recommend whole or any part of Contractor's Application for Payment, either partial or final.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.01 MAINTENANCE OF RECORD DOCUMENTS

A. General:

1. Promptly following Notice to Proceed, secure from Engineer at no cost to Contractor, one complete set of Contract Documents. Drawings will be full size (22"x 34").
2. Label or stamp each record document with title, "RECORD DOCUMENTS," in neat large, printed letters.
3. Record information concurrently with construction progress and within 24 hours after receipt of information that change has occurred. Do not cover or conceal Work until required information is recorded.

B. Preservation:

1. Maintain documents in a clean, dry, legible condition and in good order. Do not use record documents for construction purposes.
2. Make documents and Samples available at all times for observation by Engineer.

C. Making Entries on Drawings:

1. Using an erasable colored pencil (not ink or indelible pencil), clearly describe change by graphic line and note as required.
 - a. Color Coding:
 - 1) Green when showing information deleted from Drawings.
 - 2) Red when showing information added to Drawings.
 - 3) Blue and circled in blue to show notes.
 2. Date entries.
 3. Call attention to entry by "cloud" drawn around area or areas affected.
 4. Legibly mark to record actual changes made during construction, including, but not limited to:
 - a. Depths of various elements of foundation in relation to finished first floor data if not shown or where depth differs from that shown.
 - b. Horizontal and vertical locations of existing and new Underground Facilities and appurtenances, and other underground structures, equipment, or Work. Reference to at least two measurements to permanent surface improvements.
 - c. Location of internal utilities and appurtenances concealed in the construction referenced to visible and accessible features of the structure.

- d. Locate existing facilities, piping, equipment, and items critical to the interface between existing physical conditions or construction and new construction.
 - e. Changes made by Addenda and Field Orders, Change Order, and Engineer's written interpretation and clarification using consistent symbols for each and showing appropriate document tracking number.
5. Dimensions on Schematic Layouts: Show on record drawings, by dimension, the centerline of each run of items such as are described in previous subparagraph above.
- a. Clearly identify the item by accurate note such as "cast iron drain," "galv. water," and the like.
 - b. Show, by symbol or note, vertical location of item ("under slab," "in ceiling plenum," "exposed," and the like).
 - c. Make identification so descriptive that it may be related reliably to Specifications.

3.02 FINAL CLEANING

- A. At completion of the Work or of a part thereof and immediately prior to Contractor's request for certificate of Substantial Completion; or if no certificate is issued, immediately prior to Contractor's notice of completion, clean entire Site or parts thereof, as applicable.
1. Leave the Work and adjacent areas affected in a cleaned condition satisfactory to Owner and Engineer.
 2. Remove grease, dirt, dust, paint or plaster splatter, stains, labels, fingerprints, and other foreign materials from exposed surfaces.
 3. Repair, patch, and touch up marred surfaces to specified finish and match adjacent surfaces.
 4. Clean all windows.
 5. Clean floors.
 6. Broom clean exterior paved driveways and parking areas.
 7. Hose clean sidewalks, loading areas, and others contiguous with principal structures.
 8. Rake clean all other surfaces.
 9. Leave water courses, gutters, and ditches open and clean.
- B. Use only cleaning materials recommended by manufacturer of surfaces to be cleaned.

END OF SECTION

SECTION 01 78 23
OPERATION AND MAINTENANCE MANUALS

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Detailed information for the preparation, submission, and Engineer's review of Operations and Maintenance (O&M) Manuals, as required by individual Specification sections.

1.02 DEFINITIONS

- A. Preliminary O&M Manual: Initial and subsequent submissions for Engineer's review.
- B. Final O&M Manual: Engineer-accepted data, submitted as specified herein.
- C. Maintenance Operation: As used on Maintenance Summary Form is defined to mean any routine operation required to ensure satisfactory performance and longevity of equipment. Examples of typical maintenance operations are lubrication, belt tensioning, adjustment of pump packing glands, and routine adjustments.

1.03 SEQUENCING AND SCHEDULING

- A. Equipment and System Data:
 - 1. Preliminary O&M Manual:
 - a. Do not submit until Shop Drawing for equipment or system has been reviewed and approved by Engineer.
 - b. Submit prior to shipment date.
 - 2. Final O&M Manual: Submit Instructional Manual Formatted data and Electronic Media Formatted data prior to Substantial Completion of Project.

1.04 DATA FORMAT

- A. Prepare preliminary data in electronic media format. Prepare final data in the form of an instruction manual and in electronic media format.
- B. Instructional Manual Format:
 - 1. Binder: Commercial quality, permanent, three-ring or three-post binders with durable plastic cover.
 - 2. Size: 8-1/2 inches by 11 inches, minimum.

3. Cover: Identify manual with typed or printed title "OPERATION AND MAINTENANCE MANUAL" and list:
 - a. Project title.
 - b. Designate applicable system, equipment, material, or finish.
 - c. Identity of separate structure as applicable.
 - d. Identity of equipment name/number and Specification section.
 - e. Identify volume number if more than one volume.
4. Spine:
 - a. Project title.
 - b. Identity of equipment name/number and Specification section.
 - c. Identify volume number if more than one volume.
5. Title Page:
 - a. Contractor name, address, and telephone number.
 - b. Subcontractor, Supplier, installer, or maintenance contractor's name, address, and telephone number, as appropriate.
 - 1) Identify area of responsibility of each.
 - 2) Provide name and telephone number of local source of supply for parts and replacement.
6. Table of Contents:
 - a. Neatly typewritten and arranged in systematic order with associated and page numbers.
 - b. Identify each product by product name and other identifying numbers or symbols as set forth in Contract Documents.
7. Paper: 20-pound minimum, white for typed pages.
8. Text: Manufacturer's printed data, or neatly typewritten.
9. Three-hole punch data for binding and composition; arrange printing so that punched holes do not obliterate data.
10. Material shall be suitable for reproduction, with quality equal to original. Photocopying of material will be acceptable, except for material containing photographs.

C. Electronic Media Format:

1. Portable Document Format (PDF):
 - a. After all preliminary data has been found to be acceptable to Engineer, submit Operation and Maintenance data in PDF format on USB storage device.
 - b. Files to be exact duplicates of Engineer-accepted preliminary data. Arrange by specification number and name.
 - c. Files to be fully functional and viewable in most recent version of Adobe Acrobat.

1.05 SUBMITTALS

A. Informational:

1. Preliminary Operation and Maintenance Manual: Submit one electronic media format copy for Engineer's review.
2. Final Operation and Maintenance Manual: Submit one hard copy of the manual and two electronic copies.

1.06 DATA FOR EQUIPMENT AND SYSTEMS

A. Content For Each Unit (or Common Units) and System:

1. Product Data:
 - a. Include only those sheets that are pertinent to specific product.
 - b. Clearly annotate each sheet to:
 - 1) Identify specific product or part installed.
 - 2) Identify data applicable to installation.
 - 3) Delete references to inapplicable information.
 - c. Function, normal operating characteristics, and limiting conditions.
 - d. Performance curves, engineering data, nameplate data, and tests.
 - e. Complete nomenclature and commercial number of replaceable parts.
 - f. Original manufacturer's parts list, illustrations, detailed assembly drawings showing each part with part numbers and sequentially numbered parts list, and diagrams required for maintenance.
 - g. Spare parts ordering instructions.
 - h. Where applicable, identify installed spares and other provisions for future work (e.g., reserved panel space, unused components, wiring, terminals).
2. As-installed, color-coded piping diagrams.
3. Charts of valve tag numbers, with the location and function of each valve.
4. Drawings: Supplement product data with Drawings as necessary to clearly illustrate information.
 - a. Format:
 - 1) Provide reinforced, punched, binder tab; bind in with text.
 - 2) Reduced to 8-1/2 inches by 11 inches, or 11 inches by 17 inches folded to 8-1/2 inches by 11 inches.
 - 3) Where reduction is impractical, fold and place in 8-1/2-inch by 11-inch envelopes bound in text.
 - 4) Identify Specification section and product on Drawings and envelopes.
 - b. Relations of component parts of equipment and systems.
 - c. Control and flow diagrams.

- d. Coordinate drawings with Project record documents to assure correct illustration of completed installation.
- 5. Instructions and Procedures: Within text, as required to supplement product data.
 - a. Format:
 - 1) Organize in consistent format under separate heading for each different procedure.
 - 2) Provide logical sequence of instructions for each procedure.
 - 3) Provide information sheet for Owner's personnel, including:
 - a) Proper procedures in event of failure.
 - b) Instances that might affect validity of guarantee or Bond.
 - b. Installation Instructions: Including alignment, adjusting, calibrating, and checking.
 - c. Operating Procedures:
 - 1) Startup, break-in, routine, and normal operating instructions.
 - 2) Test procedures and results of factory tests where required.
 - 3) Regulation, control, stopping, and emergency instructions.
 - 4) Description of operation sequence by control manufacturer.
 - 5) Shutdown instructions for both short and extended duration.
 - 6) Provide pictures, images and/or diagrams with procedures.
 - 7) Summer and winter operating instructions, as applicable.
 - 8) Safety precautions.
 - 9) Special operating instructions.
 - d. Maintenance and Overhaul Procedures:
 - 1) Routine maintenance.
 - 2) Guide to troubleshooting.
 - 3) Disassembly, removal, repair, reinstallation, and re-assembly.
 - 4) Provide pictures, images and/or diagrams with procedures.

B. Content for Each Electric or Electronic Item or System:

- 1. Description of Unit and Component Parts:
 - a. Function, normal operating characteristics, and limiting conditions.
 - b. Performance curves, engineering data, nameplate data, and tests.
 - c. Complete nomenclature and commercial number of replaceable parts.
 - d. Interconnection wiring diagrams, including control and lighting systems.
- 2. Circuit Directories of Panelboards.
- 3. Electrical service.
- 4. Control requirements and interfaces.
- 5. Communication requirements and interfaces.
- 6. List of electrical relay settings, and control and alarm contact settings.

7. Electrical interconnection wiring diagram, including as applicable, single-line, three-line, schematic and internal wiring, and external interconnection wiring.
8. As-installed control diagrams by control manufacturer.
9. Operating Procedures:
 - a. Routine and normal operating instructions.
 - b. Startup and shutdown sequences, normal and emergency.
 - c. Safety precautions.
 - d. Special operating instructions.
10. Maintenance Procedures:
 - a. Routine maintenance.
 - b. Guide to troubleshooting.
 - c. Adjustment and checking.
 - d. List of relay settings, control and alarm contact settings.
11. Manufacturer's printed operating and maintenance instructions.
12. List of original manufacturer's spare parts, manufacturer's current prices, and recommended quantities to be maintained in storage.

C. Maintenance Summary:

1. Compile individual Maintenance Summary for each applicable equipment item, respective unit or system, and for components or sub-units.
2. Format:
 - a. Use Maintenance Summary Form bound with this section or electronic facsimile of such.
 - b. Each Maintenance Summary may take as many pages as required.
 - c. Use only 8-1/2-inch by 11-inch size paper.
 - d. Complete using typewriter or electronic printing.
3. Include detailed lubrication instructions and diagrams showing points to be greased or oiled; recommend type, grade, and temperature range of lubricants and frequency of lubrication.
4. Recommended Spare Parts:
 - a. Data to be consistent with manufacturer's Bill of Materials/Parts List furnished in O&M manuals.
 - b. "Unit" is the unit of measure for ordering the part.
 - c. "Quantity" is the number of units recommended.
 - d. "Unit Cost" is the current purchase price.
5. Insert the completed Maintenance Summary Form in the Maintenance Section of the OPERATION AND MAINTENANCE MANUAL.

1.07 SUPPLEMENTS

A. The supplements listed below, following “End of Section,” are part of this Specification.

1. Forms: Maintenance Summary Form.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION (NOT USED)

END OF SECTION

MAINTENANCE SUMMARY FORM

PROJECT: _____ CONTRACT NO.: _____

1. EQUIPMENT ITEM _____

2. MANUFACTURER _____

3. EQUIPMENT/TAG NUMBER(S) _____

4. WEIGHT OF INDIVIDUAL COMPONENTS (OVER 100 POUNDS) _____

5. NAMEPLATE DATA (hp, voltage, speed, etc.) _____

6. MANUFACTURER'S LOCAL REPRESENTATIVE _____

a. Name _____ Telephone No. _____

b. Address _____

7. MAINTENANCE REQUIREMENTS

| Maintenance Operation Comments | Frequency | Lubricant (If Applicable) |
|---|--|--|
| List briefly each maintenance operation required and refer to specific information in manufacturer's standard maintenance manual, if applicable. (Reference to manufacturer's catalog or sales literature is not acceptable.) | List required frequency of each maintenance operation. | Refer by symbol to lubricant required. |
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SECTION 01 88 15
ANCHORAGE AND BRACING

PART 1 GENERAL

1.01 SUMMARY

- A. This section covers requirements for anchorage and bracing of equipment, distribution systems, and other nonstructural components required in accordance with the ICC 2018 International Building Code (IBC), for seismic, wind, gravity, soil, and operational loads.

1.02 REFERENCES

- A. The following is a list of standards which may be referenced in this section:
1. American Institute of Steel Construction (AISC) 360, Specification for Structural Steel Buildings.
 2. American Society of Civil Engineers (ASCE): ASCE 7, Minimum Design Loads for Buildings and Other Structures.
 3. International Code Council (ICC): International Building Code (IBC).

1.03 DEFINITIONS

- A. Authority Having Jurisdiction (AHJ): Permitting building agency; may be a federal, state, local, or other regional department, or individual including building official, fire chief, fire marshal, chief of a fire prevention bureau, labor department, or health department, electrical inspector; or others having statutory authority. AHJ may be Owner when authorized to be self-permitting by governmental permitting agency or when no governmental agency has authority.
- B. Designated Seismic System: Architectural, electrical, and mechanical system or their components for which component importance factor, I_p , is greater than 1.0.

1.04 DESIGN AND PERFORMANCE REQUIREMENTS

- A. General:
1. Anchorage and bracing systems shall be designed by a qualified professional engineer registered in the Commonwealth of Virginia.
 2. Design anchorage into concrete including embedment in accordance with ACI 318-14; Chapter 17 (or other industry standard approved by Engineer), and Project Specifications.
 - a. Unless otherwise noted, design for cracked concrete condition.

3. Design anchorage and bracing of architectural, mechanical, and electrical components and systems in accordance with this section, unless a design is specifically provided within Contract Documents or where exempted hereinafter.
4. Design attachments, braces, and anchors for equipment, components, and distribution systems to structure for gravity, seismic, wind, and operational loads as applicable.
5. Anchor and brace piping and ductwork, whether exempt or not exempt for this section, so that lateral or vertical displacement does not result in damage or failure to essential architectural, mechanical, or electrical equipment.
6. Architectural Components: Includes, but are not limited to, nonstructural walls and elements, partitions, cladding and veneer, access flooring, signs, cabinets, suspended ceilings, and glass in glazed curtain walls and partitions.
7. Provide supplementary framing where required to transfer anchorage and bracing loads to structure.
8. Adjust equipment pad sizes or provide additional anchorage confinement reinforcing to provide required anchorage capacities.
9. Design anchorage and bracing for applicable gravity, seismic, wind, and operational loads for:
 - a. Equipment and components that weigh more than 800 pounds and have center of mass located 5 feet or less above adjacent finished floor.
 - b. Equipment weighing more than 75 pounds that has center of mass located more than 5 feet above adjacent finished floor.
 - c. Distribution systems that weigh more than 5 pounds per foot that have center of mass located more than 5 feet above adjacent finished floor.
10. For components exempted from design requirements of this section, provide bolted, welded, or otherwise positively fastened attachments to supporting structure.

B. Design Loads:

1. Gravity: Design anchorage and bracing for self-weight and superimposed loads on components and equipment.
2. Wind: Not applicable for Project.
3. Operational:
 - a. For loading supplied by equipment manufacturer for IBC required load cases.
 - b. Loads may include equipment vibration, torque, thermal effects, effects of internal contents (weight and sloshing), water hammer, and other load-inducing conditions.
 - c. Locate braces to minimize vibration to or movement of structure.

- d. For vibrating loads, use anchors meeting requirements of Section 05 05 19, Post-Installed Anchors, for anchors with designated capacities for vibratory loading per manufacturer's ICC-ES report.
- 4. Seismic:
 - a. Except as exempted below, design seismic anchorage and bracing in accordance with 2018 IBC, Section 1613, and Chapter 13 of ASCE 7 using the seismic design criteria listed in General Structural Notes on Drawings.
 - b. Design forces for anchors in concrete or masonry shall be in accordance with ASCE 7, Section 13.4.2.
 - c. The Seismic Design Category for the Project is B. In accordance with ASCE 7, Section 13.1.4, the following components are exempt from the seismic anchorage and bracing requirements of this section, except provide seismic anchorage and bracing for the specific components listed below regardless of the ASCE 7 exemption:
 - 1) Architectural Components: All components are exempted.
 - 2) Mechanical and Electrical Components: Provide seismic anchorage for the sodium hypochlorite tanks. All other components are exempted.

1.05 SUBMITTALS

A. Action Submittals:

- 1. Shop Drawings:
 - a. List of architectural, mechanical, and electrical equipment requiring Contractor-designed anchorage and bracing, unless specifically exempted.
 - b. Manufacturers' engineered hardware product data.
 - c. Attachment assemblies drawings, including connection hardware, braces, and anchors or anchor bolts for nonexempt components, equipment, and systems.
 - d. Submittal will be rejected if proposed anchorage method would create excessive stress to supporting member. Revise anchorages and strengthen structural support to eliminate overstressed condition.

B. Informational Submittals:

- 1. Anchorage and Bracing Calculations: For attachments, braces, and anchorages, include IBC and Project-specific criteria as noted on General Structural Notes on Drawings, in addition to manufacturer's specific criteria used for design; sealed by a civil engineer registered in the Commonwealth of Virginia.
- 2. Manufacturer's hardware installation requirements.

PART 2 PRODUCTS

2.01 GENERAL

- A. Design and construct attachments and supports transferring seismic and non-seismic loads to structure of materials and products suitable for application and in accordance with design criteria shown on Drawings and nationally recognized standards.
- B. Provide cast-in-place anchor bolts for anchorage of equipment to concrete or masonry in accordance with Section 05 50 00, Metal Fabrications. Provide anchor bolts of the size, minimum embedment, and spacing designated in calculations submitted by Contractor and accepted by Engineer.
- C. Provide post-installed concrete and masonry anchors for anchorage of equipment to concrete or masonry in accordance with Section 05 05 19, Post-Installed Anchors. Provide post-installed anchors of the size, minimum embedment, and spacing designated in calculations submitted by Contractor and accepted by Engineer.
- D. Do not use expansion anchors, other than undercut anchors, for nonvibration isolated mechanical equipment rated over 10 horsepower.

PART 3 EXECUTION

3.01 GENERAL

- A. Make attachments, bracing, and anchorage in such a manner that component lateral force is transferred to lateral force resisting system of structure through a complete load path.
- B. Provide snubbers in each horizontal direction and vertical restraints for components mounted on vibration isolation systems where required to resist overturning.
- C. Provide piping anchorage that maintains design flexibility and expansion capabilities at flexible connections and expansion joints.
- D. Anchor tall and narrow equipment such as motor control centers and telemetry equipment at base.
- E. Do not attach architectural, mechanical, or electrical components to more than one element of a building structure at a single restraint location where such elements may respond differently during a seismic event. Do not make such attachments across building expansion and contraction joints.

- F. Do not install components or their anchorages or restraints prior to review and acceptance by Engineer and AHJ.

3.02 FIELD QUALITY ASSURANCE

- A. In accordance with Section 05 50 00, Metal Fabrications, and Section 05 05 19, Post-Installed Anchors.

END OF SECTION

SECTION 01 91 14
EQUIPMENT TESTING AND FACILITY STARTUP

PART 1 GENERAL

1.01 DEFINITIONS

- A. Facility: Entire Project, or an agreed-upon portion, including all of its unit processes.
- B. Functional Test: Test or tests in presence of Engineer and Owner to demonstrate that installed equipment meets manufacturer's installation, calibration, and adjustment requirements and other requirements as specified.
- C. Performance Test: Test or tests performed after any required functional test in presence of Engineer and Owner to demonstrate and confirm individual equipment meets performance requirements specified in individual sections.
- D. Unit Process: As used in this section, a unit process is a portion of the facility that performs a specific process function, such as an individual chemical system.
- E. Performance Demonstration: A demonstration, conducted by Contractor, with assistance of Owner, to demonstrate and document the performance of a specific unit process, both manually and automatically (if required), based on criteria developed in conjunction with Owner and as accepted by Engineer. Neither the demonstration nor the evaluation is intended in any way to make performance of a unit process or entire facility the responsibility of Contractor.

1.02 SUBMITTALS

- A. Informational Submittals:
 - 1. Facility Startup and Performance Demonstration Plan.
 - 2. Functional and performance test results.
 - 3. Completed Unit Process Startup Form for each unit process.

1.03 FACILITY STARTUP AND PERFORMANCE DEMONSTRATION PLAN

- A. Develop a written plan, in conjunction with Engineer and Owner's operations personnel; to include the following:
 - 1. Step-by-step instructions for startup of each unit process.
 - 2. Unit Process Startup Form (sample attached), to minimally include the following:
 - a. Description of the unit process, including equipment numbers/nomenclature of each item of equipment and all included devices.
 - b. Detailed procedure for startup of the unit process, including valves to be opened/closed, order of equipment startup, etc.
 - c. Startup requirements for each unit process, including water, power, chemicals, etc.
 - d. Space for evaluation comments.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.01 GENERAL

- A. Unit Process Startup Meetings: Schedule with Engineer to discuss test schedule, test methods, materials, chemicals and liquids required, facilities operations interface, and Owner involvement. Schedule meeting at least seven days prior to testing.
- B. Provide temporary valves, gauges, piping, test equipment and other materials and equipment required for testing and startup.
- C. Provide Subcontractor and equipment manufacturers' staff adequate to prevent delays. Schedule ongoing work so as not to interfere with or delay testing and startup.
- D. Owner will:
 - 1. Provide water, power, chemicals, and other items as required for startup, unless otherwise indicated.
 - 2. Operate process units and facility with support of Contractor.

3.02 EQUIPMENT TESTING

A. Preparation:

1. Complete installation before testing.
2. Furnish qualified manufacturers' representatives, when required by individual Specification sections.
3. Obtain and submit from equipment manufacturer's representative Manufacturer's Certificate of Proper Installation Form, in accordance with Section 01 43 33, Manufacturers' Field Services, when required by individual Specification sections.
4. Equipment Test Report Form: Provide written test report for each item of equipment to be tested, to include the minimum information:
 - a. Owner/Project Name.
 - b. Equipment or item tested.
 - c. Date and time of test.
 - d. Type of test performed (Functional or Performance).
 - e. Test method.
 - f. Test conditions.
 - g. Test results.
 - h. Signature spaces for Contractor and Engineer as witness.
5. Cleaning and Checking: Prior to beginning functional testing:
 - a. Calibrate testing equipment in accordance with manufacturer's instructions.
 - b. Inspect and clean equipment, devices, connected piping, and structures to ensure they are free of foreign material.
 - c. Lubricate equipment in accordance with manufacturer's instructions.
 - d. Turn rotating equipment by hand when possible to confirm that equipment is not bound.
 - e. Open and close valves by hand and operate other devices to check for binding, interference, or improper functioning.
 - f. Check power supply to electric-powered equipment for correct voltage.
 - g. Adjust clearances and torque.
 - h. Test piping for leaks.
6. Ready-to-test determination will be by Engineer based at least on the following:
 - a. Acceptable Operation and Maintenance Data.
 - b. Notification by Contractor of equipment readiness for testing.
 - c. Receipt of Manufacturer's Certificate of Proper Installation, if so specified.
 - d. Adequate completion of work adjacent to, or interfacing with, equipment to be tested.
 - e. Availability and acceptability of manufacturer's representative, when specified, to assist in testing of respective equipment.

- f. Satisfactory fulfillment of other specified manufacturer's responsibilities.
- g. Equipment and electrical tagging complete.
- h. Delivery of all spare parts and special tools.

B. Functional Testing:

- 1. Conduct as specified in individual Specification sections.
- 2. Notify Owner and Engineer in writing at least 14 days prior to scheduled date of testing.
- 3. Prepare Equipment Test Report summarizing test method and results.
- 4. When, in Engineer's opinion, equipment meets functional requirements specified, such equipment will be accepted for purposes of advancing to performance testing phase, if so required by individual Specification sections. Such acceptance will be evidenced by Engineer/Owner's signature as witness on Equipment Test Report.

C. Performance Testing:

- 1. Conduct as specified in individual Specification sections.
- 2. Notify Engineer and Owner in writing at least 14 days prior to scheduled date of test.
- 3. Performance testing shall not commence until equipment has been accepted by Engineer as having satisfied functional test requirements specified.
- 4. Type of fluid, gas, or solid for testing shall be as specified.
- 5. Unless otherwise indicated, furnish labor, materials, and supplies for conducting the test and taking samples and performance measurements.
- 6. Prepare Equipment Test Report summarizing test method and results.
- 7. When, in Engineer's opinion, equipment meets performance requirements specified, such equipment will be accepted as conforming to Contract requirements. Such acceptance will be evidenced by Engineer's signature on Equipment Test Report.

3.03 STARTUP OF UNIT PROCESSES

- A. Prior to unit process startup, equipment within unit process shall be accepted by Engineer as having met functional and performance testing requirements specified.
- B. Startup sequencing of unit processes shall be as chosen by Contractor to meet schedule requirements, and as developed in the Facility Startup and Performance Demonstration Plan in conjunction with Engineer and Owner.
- C. Make adjustments, repairs, and corrections necessary to complete unit process startup.

- D. Startup shall be considered complete when, in opinion of Engineer, unit process has operated in manner intended for 5 continuous days without significant interruption. This period is in addition to functional or performance test periods specified elsewhere.
- E. Significant Interruption: May include any of the following events:
 - 1. Failure of Contractor to provide and maintain qualified onsite startup personnel as scheduled.
 - 2. Failure to meet specified functional operation for more than 2 consecutive hours.
 - 3. Failure of any critical equipment or unit process that is not satisfactorily corrected within 4 hours after failure.
 - 4. Failure of any noncritical equipment or unit process that is not satisfactorily corrected within 8 hours after failure.
 - 5. As determined by Engineer.
- F. A significant interruption will require startup then in progress to be stopped. After corrections are made, startup test period to start from beginning again.

3.04 SUPPLEMENTS

- A. Supplements listed below, following “End of Section,” are a part of this Specification:
 - 1. Unit Process Startup Form.

END OF SECTION



UNIT PROCESS STARTUP FORM

OWNER: _____ PROJECT: _____

Unit Process Description: (Include description and equipment number of all equipment and devices):

Startup Procedure (Describe procedure for sequential startup and evaluation, including valves to be opened/closed, order of equipment startup, etc.):

Startup Requirements (Water, power, chemicals, etc.): _____

Evaluation Comments: _____

**SECTION 02 41 00
DEMOLITION**

PART 1 GENERAL

1.01 DESCRIPTION

A. Scope:

1. Furnish all labor, materials, equipment and incidentals required for demolition, removal, repair and disposal.
2. The extent of this work is as follows:
 - a. Demolition, including removals, as shown on the Drawings and specified herein.
 - b. Demolition and removal of existing materials, equipment, and appurtenances.
 - c. Provide work necessary to install the new Work and to connect with existing work in an approved manner as shown and specified.
 - d. The Drawings were prepared from record drawings prepared by others and may not show all required demolition. Additional demolition may be required depending on selected equipment and approved layouts. Contractor shall field verify existing conditions and extent of demolition requirements based on approved Submittals.

B. Description:

1. Demolition includes all structural concrete, equipment, appurtenances, piping, supports, electrical, etc., and similar existing facilities.
2. Also included is the patching, filling and finishing to a smooth surface of the perimeter of all openings made and the finishing of surfaces roughened or left exposed by the demolition work. Comply with the Typical Details and other notes and details on Drawings.
3. Also included are all temporary or permanent supports required because of the demolition work.
4. Also included is the removal and relocation or rerouting of any existing piping, ductwork, valves, conduit, equipment, and appurtenances which are not specifically shown on the drawings or described in the specifications but are found to interfere with the installation of or required for connection to new piping, equipment, or other work included in this project.
 - a. As used above, the terms “relocation”, “rerouting” and “connection” shall include the furnishing and installation of all new piping, conduits, wires, insulation, and the like; with all new fittings, gaskets, supports, anchors, fasteners, painting, and miscellaneous appurtenances required in order to relocate, reroute or connect the system or equipment as necessary to return the

- system or equipment to service capable of providing the full range of service and function originally intended.
- b. All new materials shall meet the requirements of similar materials specified in these Specifications. Removed existing materials shall not be reused unless specifically called out to be “removed and reinstalled.”
 - c. Use materials compatible with new and existing piping or conduit, as approved by the Engineer, when making connections to existing piping and conduit.
5. Conform to the requirements of this section for all references to demolition and removals in other sections.
- C. Examination of Work Site: The Contractor is required to visit the work site during the bidding period to determine the hazards, working conditions, accessibility and true extent of the work required under this section.

1.02 SUBMITTALS

A. Informational Submittals:

1. Comply with Section 01 11 00, Summary of Work, Section 01 33 00, Submittal Procedures, and Section 01 31 13, Project Coordination.
2. Submit proposed Demolition/Renovation Plan, in accordance with requirements specified herein, for approval before such Work is started. Renovation plan shall include plan drawings and details of temporary pipe supports, temporary piping connections and dust containment required for completion of demolition Work.
3. Submit for review proposed methods, equipment, and operations sequence.
4. Submit copies of any notifications, authorizations and permits required to perform the Work.
5. Include coordination for shut-off, capping, temporary services, continuation of utility services, and other applicable items to ensure no interruption of Owner's operations.
6. Include statements affirming Contractor inspection of the existing roof deck, floors, walls, and framing members, and their suitability to perform as a safe working platform or, if inspection reveals a safety hazard to workers, state provisions for securing the safety of the workers throughout the performance of the Work.
7. Submit proposed methods of temporary protection for buildings and areas exposed to the weather due to demolition work and roofing work.
8. Submit temporary pipe and structural supports required to complete demolition work. Provide calculations and plans stamped by a professional engineer licensed in the State of Connecticut.

1.03 JOB CONDITIONS

A. Examination and Verification of Condition:

1. The Contractor is required to visit the work site during the bidding period to determine the hazards, working conditions, accessibility, and true extent of the demolition work required under this Section.
2. Before demolition begins, the Contractor shall inspect existing structures, equipment, and paving that will remain in place within and adjacent to the demolition area for existing defects and damage.
 - a. Record and document existing physical and operational condition of all adjacent equipment and notify the Owner of defects and damage found during this inspection.
 - b. Provide photographic documentation.

B. Scheduling:

1. Conduct work so as to avoid interference with operations and work in the existing facilities.
2. Include provision for temporary services, as required, to ensure no interruption of Owner operations.
3. Conduct work so as to expedite the renovations required to the existing facility.
4. Comply with the staged construction/demolition requirements as outlined on Drawings, as described in Section 01 91 14, Equipment Testing and Facility Startup, and elsewhere in the Contract Documents.

C. Notification:

1. Do not start any equipment removal or demolition operations without the permission of the Owner.
2. Provide outage requests and work plans for any demolition work affecting routine Plant operations, maintenance, de-energizing of existing equipment or facilities and safe access to process equipment and facilities.
3. Notify the Owner in writing at least 14 days prior to the actual start of any segment of demolition or removal work. Include an estimate of the anticipated number of hours per day and/or work-shifts per day required in order to complete each segment of demolition or removal work.

D. Protection:

1. Execute the demolition and removal Work to prevent damage or injury to structures, occupants thereof and adjacent features which may result from falling debris or other causes, and so as not to interfere with the use, and free and safe passage to and from adjacent structures.
2. Do not close or obstruct roadways, sidewalks or passageways adjacent to the Work by the placement or storage of materials.
3. Conduct all operations with a minimum interference to traffic.

4. Erect and maintain barriers, lights, sidewalk sheds, and other required protective devices.
5. Promptly repair damage done to facilities that are to remain, and to all property belonging to the Owner or occupants of the facilities.
6. Contamination:
 - a. Contractor shall insure that no demolition debris falls into or otherwise contaminates operating processes, channels, stormwater infrastructure, streams, or buildings not released for demolition.
 - b. Contractor shall immediately remedy and bear all costs of decontamination.
 - c. Demolition within operating buildings shall be completely contained.
 - d. All demolition within process buildings shall be completely contained to the immediate area.
7. Provide scaffolding, protection coverings, temporary walks, shoring, and bracing during demolition to protect personnel, structures and equipment.
8. Provide adequate lighting at all times during demolition operations.
9. Provide and maintain barriers of cloth, plastic, or wood to contain and prevent spread of debris and dust associated with the demolition area.
10. Provide dust and debris covers for mechanical and electrical equipment within the demolition area that will remain in place or be salvaged.
11. Provide warning signs, as required, for personnel and the public.
12. Provide temporary supports and bracing of all existing structures, equipment, and utilities that will remain in service.
13. Provide temporary weather protection for areas within structures made open to the elements due to demolition. Provide heat sources to maintain area at or above 50 degrees F and to prevent freezing of piping.
14. Provide adequate drainage.
15. Assure proper lock-out, tag-out procedures are in effect prior to removing electrical equipment, services, and powered equipment.

E. Explosives: The use of explosives is not permitted on the job site.

1.04 QUALITY ASSURANCE

- A. Reference Standards: Comply with all Federal, State laws or ordinances, as well as applicable codes, standards, regulations and/or regulatory agency requirements including the partial list below:
 1. Occupational Safety and Health Administration (OSHA).
 2. 29 CFR Part 1926 Safety and Health Regulations for construction.
- B. Provide warning signs, barricades and safety barriers required to protect personnel and Plant operations.

- C. Provide fire safety measures at all times in areas where burning torches are being used. Maintain all these items during the demolition period.
- D. Before demolition begins, disconnect all mechanical and electrical services affected by the work. Interconnecting piping and electrical services that are to remain in service either permanently or temporarily shall be capped, rerouted in a manner that will not interfere with the operation of the existing facilities to remain and the demolition work.
- E. Erosion control practices must be installed prior to site demolition activities, or demolition activities which include a risk of materials not remaining contained within an existing building.
- F. Carry out the demolition in such a manner that adjacent structures, which are to remain, are not endangered. Schedule the demolition work so as not to interfere with the day to day operation of the existing facilities. Do not block doorways or passageways in the existing facilities.
- G. The Contractor shall be required to provide dumpsters for the demolished materials and shall remove the materials on a weekly basis.
- H. Provide dust control. All dust generated by demolition occurring within process buildings shall be completely contained and removed from the building.
- I. Perform testing and air purging where the presence of hazardous material, gases, flammable materials or dangerous substance is apparent or suspected. Eliminate the hazard before demolition is started.
- J. Welders shall be certified by the American Welding Society.

1.05 COORDINATION

- A. Review the demolition requirements described in other Sections of the Specifications or shown on the Drawings and coordinate with the general work requirements in this Section. Unless more specific direction is given by a particular project specification or drawing detail, the requirements of this Section shall govern insofar as they pertain to the repair of surfaces that are exposed by the demolition, or which will remain exposed upon the completion of this Contract. The Contractor shall coordinate the phasing of work in order to maintain plant operations.
- B. The Contractor shall be responsible for providing all minor repairs, patches, and cover plates, whether specifically shown/described or not.
- C. The Contractor shall be responsible for any additional or differing demolitions, removals, and subsequent repair of exposed surfaces which may

be found necessary due to the selection of alternate equipment or the requirements of miscellaneous appurtenances of the equipment specified.

- D. All minor work and utilities, including electrical and instrumentation, shall be provided concurrently as required to service the respective equipment. Also, all work shall be phased to service the plant operations when required.
- E. Due to obstructions or timing, some permanent connection may be impractical at the time required. The Contractor shall make any temporary connections required or shown for the work sequence shown. Temporary connecting piping may be hose, PVC, or any material the Contractor selects, provided it is appropriate for the service intended and is approved by the Owner. Any temporary electrical connections shall comply with the National Electrical Code requirements.
- F. Any removal and/or connections which require downtime for any treatment equipment shall be scheduled in advance with the Owner.

PART 2 PRODUCTS

2.01 PRODUCTS

- A. For concrete, comply with Section 03 30 10, Structural Concrete, and related Division 3 specifications.
- B. For epoxy bonding agent, comply with Section 03 30 10, Structural Concrete.
- C. For other items, comply with specification Sections and the Typical Details of the Contract Documents as applicable.

PART 3 EXECUTION

3.01 GENERAL

- A. Disposal of Removed Items:
 - 1. All FRP material, piping (including valves, meters, pumps with motors, etc., occurring in the pipelines) and all mechanical and electric equipment shall be stockpiled neatly in the Contractor's designated staging and laydown areas where ordered on the site; those that are not claimed by the Owner shall be removed from the site. Use disposal containers for storing demolished materials in staging area.
 - 2. Immediately remove from the site all concrete, brick, tile, concrete block, roofing materials, reinforcement, structural and miscellaneous metals, plaster, wire mesh and other items contained in or upon the structure unless otherwise directed by the Engineer. Do not use demolished items in backfill.

3. Offsite disposal shall be in accordance with the following paragraph "Offsite Disposal."
- B. Demolished items are to remain property of the Contractor. Contractor shall remove all demolished materials and equipment in accordance with the following paragraph 3.01.C.
1. Equipment designated to be removed and disposed of shall become the Contractor's property and shall be disposed of offsite in accordance with all applicable regulations.
- C. Offsite Disposal:
1. Immediately dispose of all demolition materials, debris, old concrete, and unclaimed piping and equipment off the site.
 2. Dispose of debris which is not to remain the property of the Owner in conformance with all existing applicable laws and regulations.
 3. Obtain permit or written permission of the property owner or governing entity on whose property the materials and debris are placed. Furnish copy to the Owner.
- D. Exposed Surfaces:
1. Repair all surfaces of walls, floors, ceilings or other areas which are exposed by any of the removals specified herein, and which will remain as architecturally finished surfaces and which have holes, scars, chipped or other roughened or damaged surfaces revealed by the removal.
 2. Use the same or matching materials as the existing surface or as may be otherwise directed by the Engineer.
 3. Where the use of matching materials are not available or where their use is not feasible or practical, or where so indicated or directed by the Engineer or Owner's representative, stainless steel cover plates shall be used to conceal scarred surfaces or openings. Cover plates shall be brushed satin finish, gasketed, and attached to the existing surface with countersunk stainless steel screws.
 4. Repair all surfaces of walls, floors, columns, ceilings, or other such surfaces which currently have holes, anchors, scars, chips, or other damaged surfaces after removal is completed.
- E. Pollution Controls:
1. Use water sprinkling, temporary enclosures, and other suitable methods to limit the amount of dust and dirt rising and scattering in the air to the lowest practical level.
 - a. Do not use water when it may create hazardous or objectionable conditions such as ice, flooding, and pollution.

- b. Clean adjacent structures, facilities, and improvements of dust, dirt, and debris caused by demolition operations at the end of each day.
 - c. Do not allow removed equipment, masonry, concrete, etc. to accumulate in the work areas and obstruct safe passage or ongoing plant operations. Remove all debris and major pieces of piping and equipment at the end of each day's activities.
 - d. Upon completion of removal operations in the area, clean and return adjacent areas to conditions existing prior to the start of the work.
2. Comply with governing regulations pertaining to environmental protection, including erosion control regulations and the requirements of the project's stormwater pollution prevention plan.

F. Guardrail and Handrail Demolition:

1. When removal limit is to a point within 9 inches from a remaining post, the remaining horizontal rails shall have caps or plugs welded in place, ground smooth and coated liberally with zinc rich paint (steel rail) or polyamide epoxy (aluminum rail).
2. When removal limit is to a point between 9 and 24 inches from a remaining post, the rails shall be miter cut and a miter cut vertical member shall be welded across their ends to form a return. All edges and welds shall be ground smooth and coated as in 1 above.
3. When removal limit is to a point beyond 24 inches from a remaining post, a new post shall be provided grouted into a cored hole and welded to the miter-cut top rail and V-cut lower rails. Finishing shall be as described in the preceding two paragraphs.
4. In lieu of miter cuts and welding, slip-on set-screw fastened fittings conforming to the new handrail specification may be used.

- G. Miscellaneous: All piping, equipment, conduit, etc., which is supported by equipment to be removed, but which is not scheduled for removal or relocation itself, shall be temporarily supported until such time as it can be permanently supported by new equipment or construction in the area. If such permanent support cannot be obtained from the new equipment or construction, provide new supports or relocate the piping, equipment or conduit to areas where acceptable support may be obtained, all as directed by the Engineer.

3.02 STRUCTURAL REMOVALS

A. Sequence:

1. The extent of structural demolition at any floor level or area shall first be outlined by the Contractor using chalk lines, tape, or similar nonpermanent markers to demonstrate to the Owner's Representative or Engineer that the true extent and nature of the removal is completely understood. The floor level or area shall be X-rayed and marked as

- required to show critical areas of reinforcement steel and any electrical conduit.
2. After review of the outlined areas, the Owner's Representative or Engineer will advise of corrections, if any, and will discuss with the Contractor any specific details, procedures, barricades, weather protection, equipment protection, etc., required to conduct the demolition in a safe and expedient manner. Once satisfied as to the Contractor's general plan of operation, the Owner's Representative or Engineer will issue written notification to proceed with the demolition of the area.
 3. The Contractor shall first provide an approximately 1-inch deep sawcut along the outline of the area to be demolished. The sawcut shall be required along all exposed surfaces, except at such locations where the cutting equipment cannot reach. In all cases, the sawcut shall NOT cut through existing reinforcing steel, or structural supports, unless specifically indicated to, or unless directed by the Owner's Representative or Engineer. Do NOT saw beyond the limits of demolition.
 4. Following the saw-cutting of an area, the Contractor shall proceed with the main demolition using equipment and methods determined to be suitable for each particular area's application.
 5. Limits of Removal:
 - a. Remove structures to the lines and grades shown, unless otherwise directed by the Owner's Representative or Engineer.
 - b. Where no limits are shown, use limits of 6 inches outside the item to be installed. Removal of structures or masonry beyond these limits is at the Contractor's expense and these excess removals shall be reconstructed to the satisfaction of the Owner's Representative or Engineer with no additional compensation to the Contractor.
 6. Disposal of Materials:
 - a. Remove and take from the site all concrete, brick, tile, concrete block, roofing materials, reinforcement, structural or miscellaneous metals, plaster, wire mesh, and other items contained in or upon the structures, unless otherwise directed by the Owner's Representative or Engineer.
 - b. Demolished material shall not be used as fill or backfill.
- B. Junction Points: Neatly repair the point of junction after removal of parts or all of masonry walls, slabs and like work which tie into new Work or existing work, so as to leave only finished edges and surfaces exposed.

- C. Openings: Use new masonry, concrete or metal to dress the jambs, sills and heads of all new windows, passageways, doors, and other openings cut into new Work or existing work, to provide a smooth, finished appearance.
 - 1. Fill holes and depressions caused by previous physical damage or left as a result of removals in existing masonry, concrete, wood, stucco, or wallboard walls with an approved patching material, applied in accordance with the manufacturer's printed instructions.
- D. Anchors: Provide new anchoring materials including bolts, nuts, hangers, welds and reinforcing steel, which are required to attach new Work to the existing work. All such anchorage into existing concrete or masonry shall be stainless steel.
- E. Exposed Steel: Steel embedded in concrete that is exposed by demolition and will remain exposed in the finished construction shall be prepared and protected in accordance with 0330-143.

3.03 EQUIPMENT TO BE REMOVED

- A. Equipment shown or designated for demolition shall be completely removed, along with all appurtenances, such as equipment bases, piping, valves, electrical equipment, conduit, wiring and controls. Demolition shall be made so as not to affect the operation of remaining equipment, unless directed otherwise by the Engineer. Electrical power supply shall be disconnected prior to removing equipment and appurtenances.
- B. Unless specifically shown or indicated otherwise, Plant Service Lines (compressed air, Plant effluent water, non-potable water, potable water etc.) are to remain in service in their current configuration. When the existing services are ongoing demolition/construction, temporary connections of these service lines to their portions of the Plant shall be provided and maintained by the Contractor until such time the lines can be reconnected or permanently installed as required in their new locations.
 - 1. Plant Service Lines remaining in service shall, at all times, be protected from damage during construction and from freezing throughout the duration of this Contract.
- C. Existing piping shall be protected during the demolition work, and all other work, included under this Contract. Included shall be protection from freezing.
- D. Equipment and piping shall be removed or modified as indicated or as required in order to properly install the new equipment, piping and/or supports, and appurtenances.
- E. The Contractor is cautioned that existing piping and equipment may still contain various amounts of their original contents, or may contain pockets of

trapped gas, chemical or other by-products common to a wastewater treatment plant. The Contractor shall exercise care in commencing the removal of piping or equipment and should flush or ventilate the pipes wherever possible. Use of cutting torches, abrasive cutting wheels, etc. should be done only after pipe lines have been well-ventilated. The contents of piping being removed shall be drained into containment facilities and disposed of properly as approved by the Owner's Representative or Engineer.

F. In general, the notation to remove a particular equipment item shall be interpreted to include the removal of all associated piping, bases, supports, anchors, controls, conduit, wiring and related appurtenances unless specifically designated to the contrary.

1. Concrete bases, supports and curbs, which are called to be removed, shall be completely removed down to the structural concrete surface.
2. The structural concrete shall then be neatly removed to limits approximately 6 inches beyond the bases, supports, or curb dimensions, and to a depth of approximately 2 inches.
3. Provide a shallow saw cut to define the removal limits. All existing dowels or anchor bolts shall be removed to this 2 inch depth.
4. The resulting recess in the structural concrete shall be neatly patched, with patching concrete (3/8-inch maximum pea gravel).
5. The resulting patch shall match the existing floor's appearance and slope.
6. See paragraph 3.02.C.1 above.

3.04 MECHANICAL REMOVALS

A. General:

1. Mechanical removals consist of dismantling and removing existing piping, valves, blocking, supports, and other appurtenances as specified, shown, or required for the completion of the Work.
2. It includes cutting, capping, and plugging as required, except that the cutting of existing piping for the purpose of making connections is to be included under Division 40.
3. Where piping is called to be removed, it shall include all valves, meters, blocking, supports and other accessories that occur in the pipeline.
4. When sections of piping are to be removed from existing pipelines, provide supports, temporary or otherwise, for adjacent piping to remain as needed.

B. Process Piping:

1. Remove existing process, water, chemical, gas, fuel oil and other piping not required for the new Work where shown or where it will interfere with new Work.

2. Remove piping to a point approved by the Owner's Representative or Engineer, cap and leave in place.
3. Purge and make safe all chemical and fuel lines and tanks prior to removal or capping.
4. Cut off (or detach as appropriate) and properly cap on each side of the wall, piping that is to be removed which passes through existing walls.
5. Properly cap the remaining pipe when underground piping is to be altered or removed.
6. Abandoned underground piping may be left in place unless it interferes with new Work or is shown or specified to be removed.

C. Waste and Vent Piping:

1. Remove waste and vent piping to points shown.
2. Plug pipe with cleanouts and plugs.
3. Remove vent stacks where shown which pass through existing roofs that are to remain. Properly patch and make watertight the hole in the roof that is left by the stack.

D. Potable Water Piping:

1. Conform with all applicable codes and requirements as other underground piping when making changes to potable water piping and other plumbing and heating system work.
2. Pressure test and disinfect in accordance with Division 40 and all local codes all portions of the potable water system that have been altered or opened.

3.05 ELECTRICAL REMOVALS

A. General:

1. In general, the notation to remove a piece of equipment as indicated on Drawings or in this Section shall be interpreted to also include the removal of all electrical equipment, conduit, wires and appurtenances associated with the equipment. This includes, but is not limited to: all wires and conduit unless otherwise indicated on Drawings, from the motor control center starter to the equipment; and all disconnects, remote switches and starters; all controls, alarms, junction boxes, pull boxes, conduit and wiring – both local and remote, and all supports, equipment pads, braces and hangers of the items removed.
2. Electrical removals also consist of the removal of existing distribution switchboards, control panels, motors, conduits and wires, poles and overhead wiring, panel boards, lighting fixtures, receptacles and miscellaneous electrical equipment as shown, noted, specified, or required to perform the work.

3. All lights, receptacles, control panels and any other equipment as shown on the Drawings shall be removed in order to allow the new equipment to be installed.
 4. The removal of all electrical equipment and appurtenances shall be in complete conformance with the requirements of Division 26.
 5. For removal and relocation of existing electrical apparatus, comply with Section 26 05 02, Basic Electrical Requirements.
- B. Electrical Equipment and Fixtures: Remove all existing electrical equipment and fixtures where shown with such care as may be required to prevent unnecessary damage, to keep existing system in operation and to maintain the integrity of the grounding systems.
- C. Switchboards/Control Panel:
1. Remove or modify distribution switchboards as shown.
 2. Disconnect and dismantle switchboards that are to be removed and dispose of all components off the site.
 3. Remove control panels and other control equipment that will no longer be used otherwise shown or specified.
- D. Motors:
1. Disconnect and remove motors where shown or specified.
 2. Remove from the site motors not designated by the Owner to be salvaged.
 3. Store in an enclosed, heated storage area motors or other electrical gear designated for reuse.
- E. Conduit and Wire:
1. Remove completely conduits and wires where shown or associated with equipment to be removed unless all or a portion of conduit is specifically noted to remain. Contractor shall request the Owner's Representative or Engineer to accompany the Contractor while the Contractor field verifies what existing conduit is to be removed. This field verification of conduit to be removed and to remain shall precede the demolition.
 2. Cut abandoned conduits in floor or ceiling slabs, or in walls, flush with the slab or wall at the point of entrance. Plug each conduit with suitable size and type plugs and repair the area in a flush, smooth, approved manner. Unless otherwise indicated on Drawings, abandoned conduits through the roof slab shall be cut off at approximately 6 inches below the underside of the slab and suitably plugged for possible future use.
 3. Unless otherwise indicated on Drawings, disassemble and remove from the site exposed conduits and their supports.

4. Repair all areas of work to prevent rust spots on exposed surfaces and to finish affected surfaces to a smooth, clean appearance to match the surrounding surfaces.
5. Dispose of all removed wire, conduits, supports and appurtenances.

F. Panelboards:

1. Remove panelboards where shown and dispose of offsite.
2. Where shown or specified, replace with new panelboards at the same or adjacent locations.
3. Perform all cutting and patching necessary for the removal and replacement of panelboards.

G. Lighting Fixtures:

1. Remove existing lighting fixtures as shown or noted on Drawings.
2. Remove fixtures from the site that are not to be salvaged.

H. Miscellaneous Electrical Equipment:

1. Remove wall switches, receptacles, starters and other miscellaneous electrical equipment as required or as shown or noted on Drawings and dispose of off the site.
2. Remove all equipment with care so as to minimize damage to architectural and structural members. Repair any damage incurred as herein specified.

3.06 ALTERATIONS AND CLOSURES

A. General: Conform to all applicable Specifications, the Drawings, and the directions of the Owner's Representative or Engineer.

B. Cutting and Drilling:

1. Repair all holes in an approved manner.
2. Finish smoothly all repairs unless otherwise directed by the Engineer.

C. Openings:

1. Key new Work into the existing in an acceptable manner.
2. Weld new reinforcing steel to the existing reinforcing. Conform to AWS D12.1, Reinforcing Steel Welding Code.
3. In general, use the same or matching materials as the existing adjacent surface.
4. Make the finished closure a smooth, tight, sealed, permanent closure acceptable to the Engineer.

D. Painting: All surfaces exposed by the removal operations required by this contract; all plugs, seals, closure pieces, cover plates and similar equipment;

and all surfaces disturbed by the removal operations that shall remain visible or become a part of an exposed architectural surface shall be thoroughly cleaned, primed and finish painted to match existing conditions.

3.07 CLEANUP

A. General:

1. Comply with Section 01 77 00, Closeout Procedures.
2. Remove from the site all debris resulting from the demolition operations as it accumulates.
3. Upon completion of the Work, remove all materials, equipment, waste, and debris of every sort and leave the premises clean, neat and orderly.
4. Local regulations regarding hauling and disposal shall apply.

3.08 SAFETY BARRIERS

- A. Erect and maintain safety barriers, warning lights and other protective devices as required around all areas of structural demolition and/or openings in the operating floors, walls or roofs.
- B. All areas of open excavation or partially removed floors shall be kept lighted at all times, 24 hours per day, with floodlights or other lighting devices.

3.09 PROTECTION OF OPEN CHANNELS AND TANKS

- A. Provide temporary solid-surface covers (plywood, steel plate, etc.) over all open channels and tankage adjacent to demolition activities to prevent materials, demolition debris, tools, etc., from falling into the channel or tank.
- B. Exercise care to prevent loose debris, papers, wrappers, trash, containers, etc., from blowing into adjacent open channels and tankage.

END OF SECTION

SECTION 03 30 10
STRUCTURAL CONCRETE

1.01 REFERENCES

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

1. American Concrete Institute (ACI):
 - a. 117, Specifications for Tolerances for Concrete Construction and Materials.
 - b. 301, Specifications for Structural Concrete.
 - c. 305.1, Specification for Hot Weather Concreting.
 - d. 306.1, Standard Specification for Cold Weather Concreting.
 - e. 318, Building Code Requirements for Structural Concrete.
 - f. SP-66, Detailing Manual.
2. ASTM International (ASTM):
 - a. A615/A615M, Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement.
 - b. C31/C31M, Standard Practice for Making and Curing Concrete Test Specimens in the Field.
 - c. C33, Standard Specification for Concrete Aggregates.
 - d. C39/C39M, Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens.
 - e. C88, Standard Test Method for Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate.
 - f. C94/C94M, Standard Specification for Ready-Mixed Concrete.
 - g. C143/C143M, Standard Test Method for Slump of Hydraulic-Cement Concrete.
 - h. C150, Standard Specification for Portland Cement.
 - i. C192/C192M, Standard Practice for Making and Curing Concrete Test Specimens in the Laboratory.
 - j. C227, Standard Test Method for Potential Alkali Reactivity of Cement-Aggregate Combinations (Mortar-Bar Method).
 - k. C231, Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method.
 - l. C260, Standard Specification for Air-Entraining Admixtures for Concrete.
 - m. C309, Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete.
 - n. C311, Standard Test Methods for Sampling and Testing Fly Ash or Natural Pozzolans for Use as a Mineral Admixture in Portland Cement Concrete.
 - o. C452, Standard Test Method for Potential Expansion of Portland-Cement Mortars Exposed to Sulfate.
 - p. C494/C494M, Standard Specification for Chemical Admixtures for Concrete.

- q. C595, Standard Specification for Blended Hydraulic Cements.
- r. C618, Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete.
- s. C989, Standard Specification for Slag Cement for Use in Concrete and Mortars.
- t. C1012, Standard Test Method for Length Change of Hydraulic-Cement Mortars Exposed to a Sulfate Solution.
- u. C1157, Standard Performance Specification for Hydraulic Cement.
- v. C1218/C1218M, Standard Test Method for Water-Soluble Chloride in Mortar and Concrete.
- w. C1260, Standard Test Method for Potential Alkali Reactivity of Aggregates (Mortar-Bar Method).
- x. C1293, Standard Test Method for Determination of Length Change of Concrete Due to Alkali-Silica Reaction.
- y. C1315, Standard Specification for Liquid Membrane-Forming Compounds Having Special Properties for Curing and Sealing Concrete.
- z. C1567, Standard Test Method for Determining the Potential Alkali-Silica Reactivity of Combinations of Cementitious Materials and Aggregate (Accelerated Mortar-Bar Method).
- aa. C1602/C1602M, Standard Specification for Mixing Water Used in the Production of Hydraulic Cement Concrete.
- bb. D994, Standard Specification for Preformed Expansion Joint Filler for Concrete (Bituminous Type).
- cc. D1751, Specification for Preformed Expansion Joint Filler for Concrete Paving and Structural Construction (Nonextruding and Resilient Bituminous Types).
- dd. E329, Standard Specification for Agencies Engaged in Construction Inspection, Testing, or Special Inspection.
- 3. Concrete Reinforcing Steel Institute (CRSI):
 - a. Manual of Standard Practice.
 - b. Recommended Practice for Placing Reinforcing Bars.
- 4. National Ready Mixed Concrete Association (NRMCA).

1.02 SUBMITTALS

A. Action Submittals:

- 1. Reinforcing steel prepared in accordance with CRSI Manual of Standard Practice and ACI SP-66 Detailing Manual:
 - a. Bending lists.
 - b. Placing drawings.

2. Mix Designs:
 - a. Concrete mix designs shall contain proportions of materials and admixtures to be used on Project, signed by mix designer.
 - b. Documentation of average strength for each proposed mix design in accordance with ACI 301.
 - c. Mill test reports for cementitious materials.
 - d. Aggregate test reports.
 - e. Manufacturer's catalog cut sheets and product data sheets for each admixture used in proposed mix designs.
3. Product Data: Specified ancillary materials.
4. Proposed curing methods.

B. Informational Submittals:

1. Manufacturers' Letter of Certification:
 - a. Portland cement.
 - b. Fly ash.
 - c. Slag cement.
 - d. Aggregates.
 - e. Admixtures.
2. Manufacturer's application instructions for curing compound.
3. Ready-mix delivery tickets for each truck in accordance with ASTM C94.
4. Statement of Qualifications: Independent inspection and testing agency.
5. Concrete test reports prepared by independent inspection and testing agency.

1.03 QUALITY ASSURANCE

- A. Concrete construction shall conform to requirements of ACI 117 and ACI 301, except as modified herein.
- B. Qualifications:
 1. Independent Inspection and Testing Agency: Meet criteria stated in ASTM E329.

1.04 DELIVERY, STORAGE, AND HANDLING

- A. Unload, store, and handle bars in accordance with CRSI publication "Placing Reinforcing Bars."

PART 2 PRODUCTS

2.01 GENERAL

- A. Products shall be in accordance with requirements of ACI 301 unless otherwise noted.

2.02 FORMWORK

A. Form Materials:

1. For exposed areas, use hard plastic finished plywood overlaid waterproof particle board, or steel in “new and undamaged” condition, of sufficient strength and surface smoothness to produce specified finish.
2. For unexposed areas, use new shiplap or plywood.
3. Earth cuts may be used for forming footings.

B. Beveled Edge Corner Strips: Nonabsorbent material, compatible with form surface, fully sealed on all sides prohibiting loss of paste or water between the two surfaces.

2.03 CONCRETE

A. Ready-mixed meeting ASTM C94, Option C.

B. Materials: Unless otherwise specified, in accordance with ACI 301.

1. Portland Cement: ASTM C150, Type II, with maximum 0.60 percent alkalis.
2. Fly Ash: ASTM C618, Class F, with maximum 3 percent loss on ignition and 8 percent maximum calcium oxide (CaO).
3. Slag Cement: ASTM C989, Grade 100 or Grade 120.
4. Aggregates: ASTM C33.
5. Admixtures:
 - a. Air-Entraining: ASTM C260.
 - b. Water-Reducing: ASTM C494, Type A or Type D.
 - c. Superplasticizers: ASTM C494, Type F or Type G.
6. Mixing Water and Ice: Use potable water.

C. Mix Design:

1. Minimum Allowable 28-day Compressive Field Strength: 4,500 psi when cured and tested in accordance with ASTM C31 and ASTM C39.
2. Water-Cementitious Materials Ratio: 0.40 maximum for concrete with superplasticizers, 0.45 maximum for concrete without superplasticizers.
3. Cement Content: 540 pounds per cubic yard, minimum.
4. Coarse Aggregate Size: 1 inch and smaller.
5. Slump Range: 3 to 5 inches for concrete without superplasticizers, 5 to 8 inches for concrete with superplasticizers.
6. Air Content: 5 percent, plus or minus 1.5 percent when tested in accordance with ASTM C231. Limit to 3 percent maximum for interior slabs to receive a hard-troweled surface.
7. Water Reducers: Use in all concrete.
8. Superplasticizers: Use at Contractor’s option.

9. Supplemental Cementitious Materials: Include either fly ash or slag cement as partial replacement for Portland cement in the mix design.
 - a. Fly Ash: Maximum 25 percent, minimum 15 percent of total weight of fly ash plus Portland cement if used as partial replacement for Portland cement.
 - b. Slag Cement: Maximum 30 percent, minimum 20 percent of total weight of slag cement plus Portland cement if used as a partial replacement for Portland cement. Do not use fly ash if slag cement is used in mix design.

D. Concrete Mixing: In accordance with ACI 301.

2.04 REINFORCING STEEL

A. Deformed Bars: ASTM A615/A615M, Grade 60.

B. Fabrication: Follow CRSI Manual of Standard Practice.

2.05 ANCILLARY MATERIALS

A. Curing Compound:

1. Water based, high solids content nonyellowing curing compound meeting requirements of ASTM C309 except as noted below, or ASTM C1315.
 - a. Moisture Loss: 0.40 kg per square meter per 72 hours maximum.
 - b. Capable of meeting moisture retention at Manufacturer's specified application rate.
2. Manufacturers and Products:
 - a. BASF, Shakopee, MN; Masterkure.
 - b. Euclid Chemical Co., Cleveland, OH; Super Diamond Clear VOX.
 - c. WR Meadows, Inc., Hampshire, IL; VOCOMP-30.
 - d. Vexcon Chemical, Inc.; Philadelphia, PA; Starseal 1315.
 - e. Dayton Superior; Safe Cure and Seal 30%.

B. Nonshrink Grout:

1. Nonmetallic, nongas-liberating.
2. Prepackaged natural aggregate grout requiring only the addition of water.
3. Aggregate shall show no segregation or settlement at fluid consistency at specified times or temperatures.
4. Minimum strength of fluid grout, 3,500 psi at 1 day, 4,500 psi at 3 days, and 7,500 psi at 28 days.
5. Manufacturers and Products:
 - a. BASF Building Systems, Inc., Shakopee, MN; Master Flow 928.
 - b. Five Star Products Inc., Fairfield, CT; Five Star Fluid Grout 100.

- c. Euclid Chemical Co., Cleveland, OH; Hi Flow Grout.
 - d. Dayton Superior Corp., Kansas City, KS; Sure Grip High Performance Grout.
- C. Repair Mortar:
- 1. One-component, cement-based, shrinkage-compensated repair mortar system.
 - 2. Manufacturers and Products:
 - a. Vertical and Overhead Repairs:
 - 1) BASF Building Systems, Shakopee, MN; EMACO S88-CI.
 - 2) Sika Corp., Lyndhurst, NJ; SikaRepair 224.
 - b. Horizontal Repairs:
 - 1) BASF Building Systems, Shakopee, MN; EMACO S66-CI, or approved equal.
 - 2) Euclid Chemical Co., Cleveland, OH; Eucocrete Supreme.
- D. Sealant:
- 1. One-Part Polyurethane, Immersible Sealant:
 - a. Polyurethane base, single-component, moisture curing; ASTM C920, Type S, Grade NS or P, Class 25.
 - b. Capable of being continuously immersed in water.
 - c. Manufacturers and Products for Nonsag:
 - 1) Sika Chemical Corp.; Sikaflex 1a.
 - 2) Tremco; Vulkem 116.
 - d. Manufacturers and Products for Self-leveling:
 - 1) BASF; MasterSeal, SL 1.
 - 2) Tremco; Vulkem 45.
 - 3) Sika Chemical Corp.; Sikaflex 1c SL.
 - 2. Backup Material:
 - a. Nongassing, extruded, closed-cell round polyurethane foam or polyethylene foam rod, compatible with sealant used, and as recommended by sealant manufacturer.
 - b. Size: As shown or as recommended by sealant material manufacturer. Provide for joints greater than 3/16 inch wide.
 - c. Manufacturers and Products:
 - 1) BASF; Sonneborn, Sonolastic Closed-cell Backing Rod.
 - 2) Tremco; Closed-cell Backing Rod.
 - 3) Pecora Corporation; Green Rod.

PART 3 EXECUTION

3.01 GENERAL

- A. Execution shall be in accordance with requirements of ACI 301 unless otherwise noted.

3.02 FORMWORK

A. Form Construction:

1. Construct forms and provide smooth-form finish in accordance with ACI 301.
2. Form 3/4-inch bevels at exposed concrete edges, unless otherwise shown.
3. Make joints tight to prevent escape of mortar and to avoid formation of fins.
4. Brace as required to prevent distortion during concrete placement.
5. On exposed surfaces locate form ties in uniform pattern or as shown.
6. Construct so ties remain embedded in the member with no metal within 1 inch of concrete surface when forms, inserts, and tie ends are removed.

B. Form Removal:

1. Nonsupporting forms (walls and similar parts of Work) may be removed after cumulatively curing at not less than 50 degrees F for 24 hours from time of concrete placement if:
 - a. Concrete is sufficiently hard so as not to sustain damage by form removal operations.
 - b. Curing and protection operations are maintained.
2. Remove forms with care to prevent scarring and damaging the surface.
3. Prior to form removal, provide thermal protection for concrete being placed under the requirements of cold weather concreting.

3.03 PLACING REINFORCING STEEL

A. Unless otherwise specified, place reinforcing steel in accordance with CRSI Recommended Practice for Placing Reinforcing Bars.

B. Splices and Laps:

1. See Drawings for lap splice lengths.
2. Tie splices with 18-gauge annealed wire as specified in CRSI Standard.

3.04 PLACING CONCRETE

A. Inspection: Notify Engineer at least 1 full working day in advance before starting to place concrete.

B. Prior to placing concrete, remove water from excavation and debris and foreign material from forms. Check reinforcing steel for proper placement and correct discrepancies.

- C. Bonding New Concrete to Old Concrete: Perform the following before depositing new concrete on old concrete:
 - 1. Clean existing surface and mechanically roughen to obtain a 1/4-inch rough profile.
 - 2. Saturate surface with water for at least 24 hours prior to placing concrete to provide saturated surface dry (SSD) condition without standing water at time of concrete placement.
 - 3. At wall construction joints, pour a cement-sand grout to minimum depth of 1 inch over surface. Proportion 1 part cement to 2.5 parts sand by weight. Limit height of concrete placed immediately on top of grout to 12 inches maximum. Thoroughly vibrate to mix concrete and grout together.
- D. Place concrete as soon as possible after leaving mixer, without segregation or loss of ingredients, without splashing forms or steel above, and in layers not over 1.5 feet deep, except for slabs which shall be placed full depth. Place and consolidate successive layers prior to initial set of first layer to prevent cold joints.
- E. Use placement devices, for example, chutes, pouring spouts, and pumps as required to prevent segregation.
- F. Vertical Free Fall Drop to Final Placement: 5 feet in forms 8 inches or less wide and 8 feet in forms wider than 8 inches, except as specified.
- G. Retempering: Not permitted for concrete where cement has partially hydrated.

3.05 CONSOLIDATION AND VISUAL OBSERVATION

- A. Consolidation Equipment and Methods: ACI 301.
- B. Provide at least one standby vibrator in operable condition at placement Site prior to placing concrete.
- C. Vibrate concrete in vicinity of joints to obtain impervious concrete.

3.06 HOT WEATHER CONCRETING

- A. Conform to ACI 305.1.

3.07 COLD WEATHER CONCRETING

- A. Conform to ACI 306.1.

3.08 FINISHING

A. Floor Slabs and Equipment Pads:

1. Screed surfaces to true level planes.
2. After initial water has been absorbed, float with wood float and trowel with steel trowel to smooth finish free from trowel marks.
3. Do not absorb wet spots with neat cement.

B. Exterior Slabs:

1. Bull float with wood float, wood trowel, and lightly trowel with steel trowel.
2. Finish with broom to obtain nonskid surface.
3. Finish exposed edges with steel edging tool.

C. Unexposed Slab Surfaces: Screed to true surface, bull float with wood float, and wood trowel to seal surface.

D. Walls:

1. Patch tie holes with repair mortar.
2. Knock off projections.
3. Cut out honeycombs and other similar defects and repair as specified in Article Repair of Concrete Surfaces.

E. Tolerances: Floors shall not vary from level or true plane more than 1/4 inch in 10 feet when measured with a straightedge.

3.09 PROTECTION AND CURING

A. Protect fresh concrete from direct rays of sunlight, drying winds, and wash by rain.

B. Keep concrete slabs continuously wet for a 7-day period. Intermittent wetting is not acceptable.

C. Use curing compound only where approved by Engineer. Use only 7-day continuous water curing where additional finishes such as sealers, hardeners, painting, or other special coatings will be applied.

D. Cure formed surfaces with curing compound applied in accordance with manufacturer's directions as soon as forms are removed, and finishing is completed.

E. Remove and replace concrete damaged by freezing.

3.10 REPAIR OF CONCRETE SURFACES

- A. Applicable for newly constructed concrete and existing concrete where repairs are required.
- B. Cut out honeycombed and defective areas.
- C. Square cut perimeter of area to be patched and remove concrete to depth as required for application of minimum thickness of repair mortar to prevent feathered edges.
- D. Prepare surface and soak area with water as recommended by repair mortar manufacturer.
- E. Patch with repair mortar in accordance with manufacturer's instructions.
- F. Finish surfaces to match adjacent concrete.
- G. Keep patches damp for minimum seven days or coat with manufacturer-approved curing compound to minimize shrinking.
- H. Patch form tie holes with repair mortar.
- I. Where cracks are deemed by Engineer as requiring structural repair, repair the cracks using epoxy injection as specified in Section 03 64 23, Epoxy Resin Injection Grouting.

3.11 NONSHRINK GROUT

- A. Mix, place, and cure nonshrink grout in accordance with grout manufacturer's written instructions.

3.12 SEALANT

- A. Use sealant to achieve required joint depths, to allow sealants to perform intended function.
- B. Install backup material as recommended by sealant manufacturer. Where possible, provide full length sections without splices; minimize number of splices.
- C. Install sealant in accordance with manufacturer's written instructions.

3.13 FIELD QUALITY CONTROL

- A. Evaluation of Concrete Field Strength: In accordance with ACI 301. Testing will be performed by Contractor-provided inspection and testing agency.

B. Contractor Responsibilities:

1. Provide adequate facilities for safe storage and proper curing of concrete test cylinders onsite for first 24 hours, and for additional time as may be required before transporting to test lab.
2. Provide concrete for testing of slump, air content, and temperature, and for making cylinders from the point of discharge into forms. When concrete is pumped, samples used shall be taken from discharge end of pump hose.

C. Responsibilities of Independent Inspection and Testing Agency Retained by Contractor and Approved by Engineer:

1. Evaluate concrete in accordance with ACI 301 and Specifications.
2. Make, cure, and test concrete specimens in accordance with ASTM C31/C31M and ASTM C39/C39M.
3. Frequency of testing may be changed at discretion of Engineer.
4. Pumped Concrete: Take concrete samples for testing of slump (ASTM C143/C143M), air content (ASTM C231), temperature (ASTM C1064), and preparation of test cylinders (ASTM C31/C31M and ASTM C39/C39M).
5. Prepare and submit test reports in accordance with ASTM E329.
6. Reject concrete represented by cylinders failing to meet strength and air content specified.

END OF SECTION

**SECTION 03 63 00
CONCRETE DOWELING**

PART 1 GENERAL

1.01 REFERENCES

- A. The following is a list of standards that may be referenced in this section:
1. American National Standards Institute (ANSI).
 2. ASTM International (ASTM):
 - a. C881/C881M, Standard Specification for Epoxy-Resin-Base Bonding Systems for Concrete.
 - b. E329, Standard Specification for Agencies Engaged in Construction Inspection, Testing, or Special Inspection.
 - c. E488, Standard Test Methods for Strength of Anchors in Concrete and Masonry Elements.
 3. International Code Council (ICC):
 - a. 2018 International Building Code (IBC).
 - b. Evaluation Services Reports.

1.02 DEFINITIONS

- A. ICC Evaluation Services Report: Published by ICC for products provided by concrete adhesive anchor manufacturers.

1.03 SUBMITTALS

- A. Action Submittals:
1. Product Data: Manufacturer's catalog information.
- B. Informational Submittals:
1. Manufacturer's instructions for preparation, placement, drilling of holes, installation of anchors and adhesive, and handling of cartridges, nozzles, and equipment.
 2. ICC Evaluation Services Report: Specific to proposed doweling system manufacturer.
 3. Statement of Qualifications: Independent inspection and testing agency.
 4. Inspection reports prepared by independent inspection and testing agency.

1.04 QUALITY CONTROL

A. Qualifications:

1. Installer: Trained and certified by manufacturer.
2. Independent Inspection and Testing Agency: Meet criteria stated in ASTM E329.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Container Markings: Include manufacturer's name, product name, batch number, product expiration date, ANSI hazard classification, and appropriate ANSI handling precautions.

B. Store adhesive components in accordance with manufacturer's written instructions.

C. Dispose of when:

1. Shelf life has expired.
2. Stored other than per manufacturer's instructions.

PART 2 PRODUCTS

2.01 MATERIALS

A. Adhesive:

1. Approved by an ICC Evaluation Services Report for conformance to 2018 IBC requirements for doweling of steel reinforcing bars in cracked concrete.
2. Suitable for long-term loads as well as for wind and seismic loads.
3. Meet requirements of ASTM C881/C881M.
4. Two-component, insensitive to moisture, designed to be used in adverse freeze/thaw environments.
5. Disposable, Self-Contained Cartridge System:
 - a. Capable of dispensing both components in proper mixing ratio.
 - b. Fit into manually or pneumatically operated caulking gun.
6. Cure Temperature, Pot Life, and Workability: Compatible for intended use and anticipated environmental conditions.
7. Manufacturers and Products:
 - a. Hilti, Inc., Tulsa, OK; HIT-RE 500-V3 (ESR-3814) or HIT-HY 200 (ESR-3187) Adhesive Anchors.
 - b. DeWalt Fasteners, Brewster, NY; Power PURE110+ Epoxy Adhesive Anchor System (ESR-3298).
 - c. Simpson Strong-Tie Co., Inc., Pleasanton, CA; SET-XP Epoxy Adhesive Anchor System (ESR-2508).

- B. Mixing Nozzles: Disposable, manufactured in several sizes to accommodate size of reinforcing dowels.
- C. Reinforcing Dowels: As specified in Section 03 30 10, Structural Concrete.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Drilling Equipment:
 - 1. Drilling Hammers for Dowel Holes:
 - a. Electric or pneumatic rotary type with medium or light impact.
 - b. Hollow drills with flushing air systems are preferred.
 - 2. Where edge distances are less than 2 inches, use lighter impact equipment to prevent microcracking and concrete spalling during drilling process.
- B. Hole Diameter: Use drill bit diameter meeting ICC Evaluation Services Report requirements and as recommended by manufacturer.
- C. Obstructions in Drill Path: When existing steel reinforcement is encountered during drilling, obtain Engineer approval for proposed fix.
- D. Doweling:
 - 1. Install per details shown on Drawings and in accordance with adhesive manufacturer's instructions.
 - 2. Dowels may be prebent prior to installation to 15 degrees to align with other bars. Do not heat dowels to bend.
 - 3. Bent Bar Dowels: Where edge distances are critical, and intersection with steel reinforcement is likely, drill hole at 10-degree angle or less and use prebent reinforcing bars.
- E. Adhesive:
 - 1. Install in accordance with written manufacturer's instructions.
 - 2. Dispense components through specially designed static mixing nozzle that thoroughly mixes components and places mixed adhesive at base of predrilled hole.

3.02 FIELD QUALITY CONTROL

- A. Responsibilities of Independent Inspection and Testing Agency Retained by Contractor and Approved by Engineer:
 - 1. Periodic inspection of dowel installation in accordance with ICC ESR requirements.

2. Observe installation in accordance with requirements of the ICC Evaluation Services Report and submit report including the following:
 - a. Product Description: Product name, rod diameter, and length.
 - b. Drill bit compliance.
 - c. Hole diameter, diameter, and depth and cleanliness.
 - d. Adhesive expiration date.
 - e. Verification of dowel installation in accordance with manufacturer's published instructions.

END OF SECTION

SECTION 03 64 23
EPOXY RESIN INJECTION GROUTING

PART 1 GENERAL

1.01 REFERENCES

- A. The following is a list of standards which may be referenced in this section:
1. ASTM International (ASTM):
 - a. C882, Standard Specification for Test Method for Bond Strength of Epoxy Resin System Used with Concrete by Slant Shear.
 - b. D570, Standard Test Method for Water Absorption of Plastics.
 - c. D638, Standard Test Method for Tensile Properties of Plastics.
 - d. D648, Standard Test Method for Deflection Temperature of Plastics under Flexural Load in the Edgewise Position.
 - e. D695, Standard Test Method for Compressive Properties of Rigid Plastics.
 - f. D790, Standard Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials.
 2. National Sanitation Foundation (NSF):
 - a. Standard 60, Standard for Drinking Water Treatment and Chemicals – Health Effects.
 - b. Standard 61, Standard for Drinking Water System Components – Health Effects.

1.02 DEFINITIONS

- A. Crack: Complete or incomplete separation of concrete into two or more parts produced by breaking or fracturing.
- B. Hydraulic Structure: Liquid containment structure and/or structure designed to mitigate liquid infiltration.
- C. Injection: Method of bonding together, addressing or eliminating leakage through cracks or joints by installing resin under pressure to fill the void in crack or joint.
- D. Joint: A planned and formed discontinuity in concrete structure at junction of adjacent and sequential concrete placements and may contain embedded waterstops.
- E. Leak or Leakage: Crack or joint exhibiting presence of moisture, sign of efflorescence, intermittently wet to touch, or continuous flow of liquid.

- F. Narrow Cracks: Width equal to or less than 0.015 inch.
- G. Wide Cracks: Wider than 0.015 inch.

1.03 SUBMITTALS

A. Action Submittals:

- 1. Specific product recommendations in writing from epoxy resin manufacturer based on the nature of the cracks to be repaired.
- 2. Product data sheets with physical and chemical properties for epoxy resin.
- 3. Technical data for metering, mixing, and injection equipment.

B. Informational Submittals:

- 1. Manufacturer's recommended surface preparation procedures and application instructions for epoxy resins.
- 2. Statements of Qualification for Epoxy Resin Injection Staff:
 - a. Injection applicator.
 - b. Injection pump operating technician.
- 3. Epoxy resin two component ratio and injection pressure test records for concrete crack repair work.

1.04 QUALITY ASSURANCE

A. Qualifications for Injection Staff:

- 1. Injection Crew and Job Foreman:
 - a. Provide written and verifiable evidence showing compliance with the following requirements:
 - 1) Licensed or certified by epoxy resin material manufacturer.
 - 2) Minimum 3 years' experience in successful epoxy injection for at least 10,000 linear feet of successful crack injection, including 2,000 linear feet of wet crack injection to stop water leakage.

1.05 PERFORMANCE REQUIREMENTS

- A. Injected Epoxy Resin: Fill cracks with minimum resin depth penetration no less than 90 percent of full thickness of concrete section.
- B. Bond Strength Test for Epoxy Resin:
 - 1. Concrete failure before resin failure.
 - 2. 1,500 psi minimum bond strength per ASTM C882 test requirements with no failure of either concrete or epoxy resin.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Packing and Shipping:

1. Package resin material in new sealed containers and label with following information:
 - a. Manufacturer's name.
 - b. Product name and lot number.
 - c. ANSI Hazard Classification.
 - d. ANSI recommended precautions for handling.
 - e. Mix ratio by volume for components.

- B. Storage and Protection: Store epoxy resin material containers in accordance with manufacturer's printed instructions and at ambient temperatures below 110 degrees F and above 45 degrees F.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Materials and accessories specified in this section shall be products of:

1. BASF Construction Chemicals, LLC-Building Systems, Shakopee, MN; SCB Concsive Series products that meet properties indicated in sub-section 2.2.B.
2. Sika Corp., Lyndhurst, NJ; Sikadur Series products that meet properties below.
3. Euclid Chemical Co., Cleveland, OH; Euco Series (#452) products that meet properties below.

2.02 EPOXY INJECTION RESIN

- A. Two-component A and B structural epoxy resin for injection into cracks in concrete structures.

B. Uncured Resin Properties:

1. When mixed in ratio specified on resin container label:

| | Test Method | Wide Cracks | Narrow Cracks |
|--|--|------------------|------------------|
| Pot Life (60-gram mass) @ 77, plus or minus 4 deg F | As specified in Article Source Quality Control | 13 to 25 minutes | 15 to 30 minutes |
| Pot Life (60-gram mass) @ 100, plus or minus 4 deg F | As specified in Article Source Quality Control | 3 to 10 minutes | 10 to 20 minutes |

| | Test Method | Wide Cracks | Narrow Cracks |
|---------------------------------------|---------------------------------------|--------------------|----------------------|
| Viscosity @ 40, plus or minus 3 deg F | Brookfield RVT Spindle No. 4 @ 20 rpm | 4,400 cps | 600 cps |
| Viscosity @ 75 to 77 deg F | Brookfield RVT Spindle No. 2 @ 20 rpm | 375 to 350 cps | 175 to 140 cps |

- C. Epoxy Resin Properties: When cured for 7 days at 77 degree F, plus or minus 3 degrees F and conditioned at test temperature 12 hours prior to test, unless otherwise specified.

| | Test Method | Wide Cracks | Narrow Cracks |
|--|--------------------|----------------------------|--------------------------|
| Ultimate Tensile Strength, psi | ASTM D368 | 8,000 min. | 5,000 min. |
| Tensile Elongation @ Break, percent | ASTM D638 | 4.2 max. | 3.0 max. |
| Flexural Strength, psi | ASTM D790 | 10,000 min. | 10,000 min. |
| Flexural Modulus, psi | ASTM D790 | 5.5 x 10 ⁵ min. | 4.5x10 ⁵ min. |
| Compressive Yield Strength, psi | ASTM D695* | 15,000 min. | 12,000 min. |
| Compressive Modulus, psi | ASTM D695* | 4.0x10 ⁵ min. | 4.0x10 ⁵ min. |
| Heat Deflection Temperature | ASTM D648* | 130 deg F min. | 140 deg F min. |
| Cured 3 days @ 40 deg F – Wet Concrete | | 3,500 psi min. | 3,500 psi min. |
| Cured 1 day @ 77 deg F – Dry Concrete | | 5,000 psi min. | 5,000 psi min. |
| Cured 3 days @ 77 deg plus or minus 3 deg F | | 5,000 psi min. | 5,000 psi min. |
| *Cure test specimens so that peak exothermic temperature of resin does not exceed 100 degrees F. | | | |
| Note: See referenced specifications for preparation method of test specimens. | | | |

2.03 SURFACE SEAL

- A. Sufficient strength and adhesion for holding injection fittings firmly in place and to resist pressures preventing leakage during injection.
- B. Capable of removal after injection resin has cured.

2.04 WATER

- A. Clean and free from oil, acid, alkali, organic matter, or other deleterious substances, meeting federal drinking water standards.

PART 3 EXECUTION

3.01 GENERAL

- A. Structurally repair cracks listed below:
 - 1. Cracks in new concrete that are 0.010-inch wide and wider.
 - 2. Cracks in existing concrete surfaces where resinous special coating per Section 09 97 00, Special Coatings, will be applied that are not covered by the general crack repair work to be performed by the coating manufacturer. Epoxy-injected cracks shall be finished to be flush with adjacent concrete surfaces.
 - 3. Cracks in existing concrete structures where shown on Drawings.
- B. Do not proceed with injection work until submittals have been reviewed and approved by Engineer.
- C. Perform crack injection work after removing defective surface materials and after performing surface preparation, but prior to applying surface repair material unless otherwise noted. See Section 03 30 10, Structural Concrete, for concrete surface repair system.
- D. Width of cracks may vary along length and through thickness of concrete section.
- E. Remove all excess, unused epoxy resin materials on concrete surfaces exposed to view prior to end of Work.

3.02 EQUIPMENT

- A. Portable, positive displacement type pumps with in-line metering to meter and mix two epoxy resin components and inject mixture into cracks or joints.
- B. Pumps:
 - 1. Electric or air powered with interlocks providing positive ratio control of proportions for the two components at nozzle.
 - 2. Primary injection pumps for each material of different mix ratio, including a standby backup pump of similar ratio.
 - 3. Capable of immediate compensation for changes in resins.
 - 4. Do not use batch mix pumps.

- C. Discharge Pressure: Automatic pressure controls capable of discharging mixed epoxy resin at pressures in accordance with epoxy resin manufacturer's printed instruction and able to maintain pressure.
- D. Automatic Shutoff Control: Provide sensors on both Component A and Component B reservoirs for stopping machine automatically when only one component is being pumped to mixing head.
- E. Proportioning Ratio Tolerance: Maintain epoxy resin manufacturer's prescribed mix ratio within a tolerance of plus or minus 5 percent by volume at discharge pressure up to 160 psi.
- F. Ratio/Pressure Check Device:
 - 1. Two independent valve nozzles capable of controlling flow rate and pressure by opening or closing valve to restrict material flow.
 - 2. Pressure gauge capable of sensing pressure behind each valve.

3.03 PREPARATION

- A. Free cracks from loose matter, dirt, laitance, oil, grease, efflorescence, salt, and other contaminants.
- B. Clean cracks in accordance with epoxy resin manufacturer's instructions.
- C. Clean surfaces adjacent to cracks from dirt, dust, grease, oil, efflorescence, and other foreign matter detrimental to bond of surface seal system and to expose the full extent of cracks and joints in accordance with manufacturer's printed instruction by low pressure water cleaning using a pressure of 1,000 psi to 3,000 psi.
- D. Do not use acids and corrosives for cleaning, other than those specified herein unless neutralized prior to injecting epoxy resin.
- E. During installation and curing of materials, if ambient temperature is expected to drop below manufacturer's recommended minimum temperature, provide enclosures and heat as required.
- F. Provide work platforms as required.
- G. Dry out cracks if required by manufacturer's instructions.

3.04 APPLICATION

- A. All liquid is to be removed from hydraulic structure prior to commencing with epoxy injection, unless approved otherwise.

B. Entry Ports:

1. Establish openings for epoxy resin entry in surface seal along crack.
2. Determine space between entry ports equal to thickness of concrete member to allow epoxy resin to penetrate to the full thickness of the member.
3. Drill injection holes at an angle between 45 degrees and 60 degrees from surface of concrete and perpendicular to alignment of cracks, to intersect crack at midpoint of concrete section, except as noted otherwise.
4. Locate drill holes on alternate sides of crack where possible, unless orientation of crack is known or has been verified by non-destructive testing techniques or core drilling.
5. Drill Hole Spacing: Do not to exceed concrete thicknesses or 12 inches maximum, except as noted otherwise.
6. Adjust location and angle of drill holes to suit orientation of crack and at commencement of drilling holes for injection and at beginning of each subsequent shift.
7. Take measures to prevent drilling holes for injection too shallow or too deep.
8. Remove dust and debris in drill holes and on surface of structure resulting from drilling operation, by flushing with water prior to installing the injection packers or ports.
9. Space entry ports closer together to allow adjustment of injection pressure to obtain minimum loss of epoxy to soil at locations where:
 - a. Cracks or joints extend entirely through concrete element.
 - b. Backfill of walls on one side.
 - c. Slab-on-grade.
 - d. Difficult to excavate behind wall to seal both surfaces of crack.
10. Install injection packers or ports in drill holes in accordance with manufacturer's printed instructions with zerk coupling or other one-way ball or check valve, to permit testing for watertightness of cracks.

C. Application of Surface Seal along Cracks:

1. Apply surface seal in accordance with manufacturer's instructions to designated cracks faces prior to injection. Seal surface of cracks to contain and prevent escape of injection epoxy.
2. Cure surface seal in accordance with manufacturer's printed instructions before commencing inject work.

D. Epoxy Injection:

1. Ensure zerk coupling is not installed in ports or packers next to the one being injected.
2. Start injection into each crack at lowest elevation entry port or packer along vertical or diagonal crack, and at one end of horizontal crack.
3. Where injection entry ports or packers are used, continue injection at first port or packer until resin begins to flow out of port or packer at next highest elevation. Plug first port or packer and start injection at second port or packer until resin flows from next port or packer.
4. Inject entire crack with same sequence.
5. At no time inject more than 6 feet length of first vertical crack before verifying resin in sample bottle has start to set and cure.
6. Prior to commencing injection work along a horizontal crack in structure when processed using ports or packers with zerk couplings are used, remove zerk couplings from injection ports or packers except for two ports or packers located where injection work will commence. Commence injection work in first two ports or packers. Once clean resin is vented from third injection port or packer, cease injection at first port or packer, and install zerk coupling and commence injection at third port or packer. Repeat process for fourth and subsequent ports or packers until full length of crack has been injected.

E. Finishing:

1. Allow epoxy resin to cure in accordance with manufacturer's instruction after cracks have been completely injected to allow surface seal removal without draining or runback of uncured epoxy resin material from cracks.
2. Remove surface seal and injection packers from cured injection resin along crack.
3. Finish crack faces flush with adjacent concrete.
4. Indentations or protrusions caused by placement of entry ports, packers, drill holes, or damage from removal of surface seal is not acceptable.
5. Grind off protrusions and patch indentations and holes from injection packers and entry ports with a suitable patch material to satisfaction of Engineer.
6. Remove surplus surface seal material splatters and injection resin material runs and spills from concrete surfaces.

3.05 FIELD QUALITY CONTROL

A. Epoxy Resin Two Component Ratio Tests:

1. Disconnect mixing head and pump two resin components simultaneously through ratio check device.

2. Adjust discharge pressure to 160 psi for both resin components.
3. Simultaneously discharge both resin components into separate calibrated containers.
4. Compare amounts simultaneously discharged into calibrated containers during same time period to determine mix ratio.
5. Complete test at 160 psi discharge pressure and repeat procedure for 0 psi discharge pressure.
6. Run ratio test for each injection unit at beginning and end of each injection work day, and when injection work has stopped for more than 1 hour.
7. Document and maintain complete accurate records of ratios and pressure checks.

B. Injection Pressure Test:

1. Disconnect mixing head of injection equipment and connect two resin component delivery lines to pressure check device.
2. Pressure Check Device:
 - a. Two independent valved nozzles capable of controlling flow rate and pressure by opening or closing of valve.
 - b. Pressure gauge capable of sensing pressure buildup behind each valve.
3. Close valves on pressure check device and operate equipment until gauge pressure on each line reads 160 psi.
4. Stop pumps and observe pressure; do not allow pressure gauge to drop below 150 psi within 3 minutes.
5. Run pressure test for each injection equipment unit:
 - a. Beginning and end of each injection work day.
 - b. When injection work stop for more than 45 minutes.
6. Check tolerance to verify equipment capable of meeting specified ratio tolerance.

END OF SECTION

SECTION 05 05 19
POST-INSTALLED ANCHORS

PART 1 GENERAL

1.01 REFERENCES

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

1. American Concrete Institute (ACI):
 - a. 318, Building Code Requirements for Structural Concrete.
 - b. 355.2, Qualification of Post-Installed Mechanical Anchors in Concrete.
 - c. 355.4, Qualification of Post-Installed Adhesive Anchors in Concrete.
2. American Iron and Steel Institute (AISI): Stainless Steel Type 316.
3. American National Standards Institute (ANSI).
4. ASTM International (ASTM):
 - a. A123/A123M, Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
 - b. A143, Practice for Safeguarding Against Embrittlement of Hot-Dip Galvanized Structural Steel Products and Procedure for Detecting Embrittlement.
 - c. A153/A153M, Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.
 - d. A193/A193M, Specification for Alloy-Steel and Stainless Steel Bolting Materials for High-Temperature Service.
 - e. A194/A194M, Specification for Carbon and Alloy Steel Nuts for Bolts for High-Pressure or High-Temperature Service, or Both.
 - f. A380, Practice for Cleaning, Descaling, and Passivation of Stainless Steel Parts, Equipment, and Systems.
 - g. A385, Practice for Providing High-Quality Zinc Coatings (Hot-Dip).
 - h. A563, Specification for Carbon and Alloy Steel Nuts.
 - i. A780, Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings.
 - j. A967, Specification for Chemical Passivation Treatments for Stainless Steel Parts.
 - k. E329, Standard Specification for Agencies Engaged in Construction Inspection, Testing, or Special Inspection.
 - l. E488, Standard Test Methods for Strength of Anchors in Concrete Elements.
 - m. F436, Specification for Hardened Steel Washers.
 - n. F468, Specification for Nonferrous Bolts, Hex Cap Screws, and Studs for General Use.

- o. F568M, Specification for Carbon and Alloy Steel Externally Threaded Metric Fasteners.
 - p. F593, Specification for Stainless Steel Bolts, Hex Cap Screws, and Studs.
 - q. F594, Specification for Stainless Steel Nuts.
 - r. F1554, Specification for Anchor Bolts, Steel, 36, 55, and 105-ksi Yield Strength.
5. International Association of Plumbing and Mechanical Officials Uniform ES (IAPMO-UES): Evaluation Reports for Concrete and Masonry Anchors.
 6. International Code Council Evaluation Service (ICC-ES):
 - a. Evaluation Reports for Concrete and Masonry Anchors.
 - b. AC01, Acceptance Criteria for Expansion Anchors in Masonry Elements.
 - c. AC70, Acceptance Criteria for Fasteners Power-driven into Concrete, Steel and Masonry Elements.
 - d. AC106, Acceptance Criteria for Predrilled Fasteners (Screw Anchors) in Masonry Elements.
 - e. AC193, Acceptance Criteria for Mechanical Anchors in Concrete Elements.
 - f. AC308, Acceptance Criteria for Post-Installed Adhesive Anchors in Concrete Elements. Evaluation Reports for Concrete and Masonry Anchors.
 7. Specialty Steel Industry of North America (SSINA):
 - a. Specifications for Stainless Steel.
 - b. Design Guidelines for the Selection and Use of Stainless Steel.
 - c. Stainless Steel Fabrication.
 - d. Stainless Steel Fasteners.

1.02 DEFINITIONS

- A. Corrosive Area: Containment area or area exposed to delivery, storage, transfer, or use of chemicals.
- B. Exterior Area: Location not protected from weather by a building or other enclosed structure to include buried roof structures.
- C. Interior Dry Area: Location inside building or structure where floor is not subject to liquid spills or wash down, and where wall or roof slab is not common to a water-holding or earth-retaining structure.
- D. Interior Wet Area: Location inside building or structure where floor is sloped to floor drains or gutters and is subject to liquid spills or wash down, or where wall, floor, or roof slab is common to a water-holding or earth-retaining structure.

- E. Submerged: Location at or below top of wall of open water-holding structure, such as a basin or channel, or wall, ceiling, or floor surface inside a covered water-holding structure, or exterior belowgrade wall or roof surface of water-holding structure, open or covered.

1.03 SUBMITTALS

A. Action Submittals:

- 1. Shop Drawings: Specific instructions for concrete anchor installation, including drilled hole size and depth, preparation, placement, procedures, and instructions for safe handling of anchoring systems.

B. Informational Submittals:

- 1. Concrete and Masonry Anchors:
 - a. Manufacturer's product description and installation instructions.
 - b. Current ICC-ES or IAPMO-UES Report for each type of post-installed anchor to be used.
 - c. Adhesive Anchor Installer Certification.
- 2. Passivation method for stainless steel members.
- 3. Statement of Qualifications: Independent inspection and testing agency.
- 4. Inspection reports prepared by independent inspection and testing agency.

1.04 QUALITY CONTROL

A. Qualifications:

- 1. Adhesive Anchor Installer: Trained and certified by manufacturer.
- 2. Independent Inspection and Testing Agency: Meet criteria stated in ASTM E329.

1.05 DELIVERY, STORAGE, AND HANDLING

- A. Package stainless steel items in a manner to provide protection from carbon impregnation.
- B. Protect hot-dip galvanized finishes from damage as a result of metal banding and rough handling.

PART 2 PRODUCTS

2.01 GENERAL

A. Unless otherwise indicated, meet the following requirements:

| Item | ASTM Reference |
|---|------------------------------------|
| Stainless Steel: | |
| Threaded Rods | F593, AISI Type 316, Condition CW |
| Nuts* | F594, AISI Type 316, Condition CW |
| Titanium: | |
| Threaded Rods and Nuts | F468, Titanium Grade 2 |
| Carbon Steel: | |
| Threaded Rods | F1554, Grade 36 or F568M Class 5.8 |
| Flat and Beveled Washers (Hardened) | F436 |
| Nuts* | A194/A194M, Grade 2H |
| Galvanized Steel: | |
| All | A153/A153M |
| *Nuts of other grades and styles having specified proof load stresses greater than specified grade and style are also suitable. Nuts must have specified proof load stresses equal to or greater than minimum tensile strength of specified threaded rod. | |

B. Bolts, Washers, and Nuts: Use stainless steel, titanium, hot-dip galvanized steel, and zinc-plated steel material types as indicated in Fastener Schedule at end of this section.

2.02 POST-INSTALLED CONCRETE ANCHORS

A. General:

1. AISI Type 316 stainless, hot-dip galvanized or zinc-plated steel, as shown in Fastener Schedule at end of this section.
2. Post-installed anchor systems used in concrete shall be approved by ICC Evaluation Services Report or equivalent for use in cracked concrete and for short-term and long-term loads including wind and earthquake.
3. Mechanical Anchors: Comply with the requirements of ICC-ES AC193 or ACI 355.2.

4. Adhesive Anchors: Comply with the requirements of ICC-ES AC308 or ACI 355.4.
- B. Torque-Controlled Expansion Anchors (Wedge Anchors):
1. Manufacturers and Products:
 - a. Hilti, Inc., Tulsa, OK; Kwik-Bolt –TZ (KB-TZ) Anchors (ESR-1917).
 - b. DeWalt/Powers Fasteners, Brewster, NY; Power-Stud +SD1, +SD2, +SD4, or +SD6 Anchors (ESR-2502 and ESR-2818).
 - c. Simpson Strong-Tie Co., Inc., Pleasanton, CA; Strong-Bolt 2 Anchors (ESR-1771 and ESR-3037).
- C. Undercut Anchors:
1. Manufacturers and Products:
 - a. USP Structural Connectors, Burnsville, MN; DUC Undercut Anchor (ESR-1970).
 - b. Hilti, Inc., Tulsa, OK; HDA Undercut Anchor (ESR-1546).
 - c. Simpson Strong-Tie Co., Inc., Pleasanton, CA; TORQ-CUT Self-Undercutting Anchor (ESR-2705).
 - d. DeWalt/Powers Fasteners, Brewster, NY; Atomic+ Undercut Anchor (ESR-3067).
- D. Self-Tapping Concrete Screw Anchors:
1. Manufacturers and Products:
 - a. DeWalt/Powers Fasteners, Brewster, NY; Wedge-Bolt+ (ESR-2526).
 - b. DeWalt/Powers Fasteners, Brewster, NY; Vertigo+ Rod Hanger Screw Anchor (ESR-2989).
 - c. DeWalt/Powers Fasteners, Brewster, NY; Snake+ Flush Mount Screw Anchor (ESR-2272).
 - d. Hilti, Inc., Tulsa, OK; HUS-EZ Screw Anchor (ESR-3027).
 - e. Simpson Strong-Tie Co., Inc., Pleasanton, CA; Titen HD Screw Anchor (ESR-2713).
- E. Adhesive Anchors:
1. Threaded Rod:
 - a. Diameter as shown on Drawings.
 - b. Length as required to provide minimum depth of embedment indicated and thread projection required.
 - c. Clean and free of grease, oil, or other deleterious material.
 2. Adhesive:
 - a. Two-component, insensitive to moisture, designed to be used in adverse freeze/thaw environments.

- b. Cure Temperature, Pot Life, and Workability: Compatible for intended use and anticipated environmental conditions.
- 3. Packaging and Storage:
 - a. Disposable, self-contained system capable of dispensing both components in proper mixing ratio and fitting into a manually or pneumatically operated caulking gun.
 - b. Store adhesive on pallets or shelving in a covered storage area.
 - c. Package Markings: Include manufacturer's name, product name, batch number, product expiration date, ANSI hazard classification, and appropriate ANSI handling precautions.
 - d. Dispose of When:
 - 1) Shelf life has expired.
 - 2) Stored other than in accordance with manufacturer's instructions.
- 4. Manufacturers and Products:
 - a. Hilti, Inc., Tulsa, OK; HIT Adhesive Anchor System, HIT RE 500 V3 (ESR-3814), or HIT-HY 200 (ESR-3187).
 - b. Simpson Strong-Tie Co., Inc., Pleasanton, CA; SET-XP Epoxy Adhesive Anchors (ESR-2508), or AT-XP Adhesive Anchors (IAPMO UES-263).
 - c. DeWalt/Powers Fasteners, Brewster NY; Pure 110+ Epoxy adhesive anchor system (ESR-3298).

F. Adhesive Threaded Inserts:

- 1. Type 316 stainless steel, internally threaded inserts.
- 2. Manufacturer and Product: Hilti, Inc., Tulsa, OK; HIS-RN Insert with HIT-RE 500-V3 or HIT-HY 200 adhesive.

2.03 POST-INSTALLED MASONRY ANCHORS

- A. General: Titanium, AISI Type 316 stainless, hot-dip galvanized, or zinc-plated steel, as shown in Fastener Schedule at end of section.
- B. Current ICC Evaluation Report indicating acceptance for anchors at structural applications in masonry.
- C. Manufacturers and Products:
 - 1. Hilti, Inc., Tulsa, OK; Kwik-Bolt-3 (KB-3) (ESR-1385), for grout-filled masonry, HIT-HY 270 (ESR-4143) for grout filled CMU, hollow CMU, or unreinforced masonry. Provide manufacturer's standard screen tubes for adhesive anchors installed in hollow CMU or unreinforced masonry.
 - 2. Simpson Strong-Tie Co., Inc., Pleasanton, CA; Strong-Bolt 2 (IAPMO ER 240) for grout filled CMU, Titen-HD (ESR-1056) for grout filled or hollow CMU, AT-XP (IAPMO ER-281) for grout filled CMU.

3. DeWalt/Powers Fasteners, Brewster NY; Power-Stud+ SD1 (ESR-2966) for grout-filled masonry, Wedgebolt+ (ESR-1678) for grout-filled masonry.

PART 3 EXECUTION

3.01 CONCRETE AND MASONRY ANCHORS

- A. Begin installation only after concrete or masonry to receive anchors has attained design strength.
- B. Locate existing reinforcing steel and embedded conduits and piping with Ground Penetrating Radar or other method approved by Engineer prior to drilling. Coordinate with Engineer to adjust anchor locations where installation would result in hitting reinforcing steel or embedded conduits and piping.
- C. Install in accordance with written manufacturer's instructions.
- D. Provide minimum embedment, edge distance, and spacing as indicated on Drawings.
- E. Use only drill type and bit type and diameter recommended by anchor manufacturer.
- F. Clean hole of debris and dust per manufacturer's requirements.
- G. When unidentified embedded steel, rebar, or other obstruction is encountered in drill path, slant drill to clear obstruction. If drill must be slanted more than indicated in manufacturer's installation instructions to clear obstruction, notify Engineer for direction on how to proceed.
- H. Adhesive Anchors:
 1. Unless otherwise approved by Engineer and adhesive manufacturer:
 - a. Do not install adhesive anchors when temperature of concrete or masonry is below 40 degrees F or above 100 degrees F.
 - b. Do not install prior to concrete attaining an age of 21 days.
 - c. Remove any standing water from hole with oil-free compressed air. Inside surface of hole shall be dry.
 - d. Do not disturb anchor during recommended curing time.
 - e. Do not exceed maximum torque as specified in manufacturer's instructions.
 2. For hollow-unit masonry, install screen tube in accordance with manufacturer's instructions.

- I. Prestressed Concrete: Do not use drilled-in anchors in prestressed or post-tensioned concrete members without Engineer's prior approval unless specifically shown on Drawings.

3.02 FIELD QUALITY CONTROL

- A. Responsibilities of Independent Inspection and Testing Agency Retained by Contractor and Approved by Engineer:
 - 1. Periodic inspection of anchor installation in accordance with ICC ESR requirements.
 - 2. Observe installation in accordance with requirements of the ICC Evaluation Services Report and submit report including the following:
 - a. Product Description: Product name, rod diameter, and length.
 - b. Drill bit compliance.
 - c. Hole diameter, diameter, and depth and cleanliness.
 - d. Adhesive expiration date for adhesive anchors.
 - e. Verification of anchor installation in accordance with manufacturer's published instructions.

3.03 MANUFACTURER'S SERVICES

- A. Adhesive Anchors: Conduct Site training of installation personnel for proper installation, handling, and storage of adhesive anchor system. Notify Engineer of time and place for sessions.

3.04 FASTENER SCHEDULE

- A. Unless indicated otherwise on Drawings, provide fasteners as follows:

| Service Use and Location | Product | Remarks |
|--|---|---|
| 1. Post-Installed Anchors for Metal Components to Cast-in-Place Concrete (such as, Ladders, Handrail Posts, Electrical Panels, Platforms, and Equipment) | | |
| Interior Dry Areas | Anchor material type to match material being anchored (for example, stainless steel anchors to anchor stainless steel equipment, zinc-plated anchors to anchor painted equipment, galvanized anchors to anchor galvanized equipment). Use titanium anchors to anchor FRP equipment. | Verify product acceptability and manufacturer's requirements if anchor installation will occur in an overhead application |

| Service Use and Location | Product | Remarks |
|--|---|---|
| Submerged, Exterior, Interior Wet, and Corrosive Areas | Titanium adhesive anchors | Verify product acceptability and manufacturer's requirements if anchor installation will occur in an overhead application |
| 2. Anchors in Grout-Filled Concrete Masonry Units | | |
| Interior Dry Areas | Anchor material type to match material being anchored (for example, stainless steel anchors to anchor stainless steel equipment, zinc-plated anchors to anchor painted equipment, galvanized anchors to anchor galvanized equipment). | |
| Submerged, Exterior, Interior Wet, and Corrosive Areas | Stainless steel adhesive anchors | |
| 3. Anchors in Hollow Concrete Masonry Units | | |
| Interior Dry Areas | Anchor material type to match material being anchored (for example, stainless steel anchors to anchor stainless steel equipment, zinc-plated anchors to anchor painted equipment, galvanized anchors to anchor galvanized equipment). | Adhesive anchors shall be installed with screen tubes. |
| Exterior, Interior Wet, and Corrosive Areas | Stainless steel adhesive anchors | Adhesive anchors shall be installed with screen tubes. |
| 4. All Others | | |
| All service uses and locations | Stainless steel fasteners | |

- B. Antiseizing Lubricant: Use on all stainless steel threads.
- C. Do not use adhesive anchors to support fire-resistive construction or where ambient temperature will exceed 120 degrees F.

END OF SECTION

SECTION 05 50 00
METAL FABRICATIONS

PART 1 GENERAL

1.01 REFERENCES

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

1. The Aluminum Association, Inc. (AA): The Aluminum Design Manual.
2. American Galvanizers Association (AGA):
 - a. Inspection of Hot-Dip Galvanized Steel Products.
 - b. Quality Assurance Manual.
3. American Iron and Steel Institute (AISI): Stainless Steel Types.
4. American Ladder Institute (ALI): A14.3, Ladders - Fixed - Safety Requirements.
5. American National Standards Institute (ANSI).
6. American Society of Safety Engineers (ASSE): A10.11, Safety Requirements for Personnel and Debris Nets.
7. American Welding Society (AWS):
 - a. D1.1/D1.1M, Structural Welding Code - Steel.
 - b. D1.2/D1.2M, Structural Welding Code - Aluminum.
 - c. D1.6/D1.6M, Structural Welding Code - Stainless Steel.
8. ASTM International (ASTM):
 - a. A36/A36M, Standard Specification for Carbon Structural Steel.
 - b. A48/A48M, Specification for Gray Iron Castings.
 - c. A53/A53M, Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless.
 - d. A108, Standard Specification for Steel Bar, Carbon and Alloy, Cold-Finished.
 - e. A123/A123M, Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
 - f. A143/A143M, Standard for Safeguarding Against Embrittlement of Hot-Dip Galvanized Structural Steel Products and Procedure for Detecting Embrittlement.
 - g. A153/A153M, Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.
 - h. A193/A193M, Standard Specification for Alloy-Steel and Stainless Steel Bolting for High Temperature or High Pressure Service and Other Special Purpose Applications.
 - i. A194/A194M, Standard Specification for Carbon and Alloy Steel Nuts for Bolts for High Pressure or High Temperature Service, or Both.
 - j. A240/A240M, Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications.

- k. A276, Standard Specification for Stainless Steel Bars and Shapes.
- l. A283/A283M, Standard Specification for Low and Intermediate Tensile Strength Carbon Steel Plates.
- m. A307, Standard Specification for Carbon Steel Bolts and Studs, 60,000 PSI Tensile Strength.
- n. A325, Standard Specification for Structural Bolts, Steel, Heat Treated 120/105 ksi Minimum Tensile Strength.
- o. A380, Standard Practice for Cleaning, Descaling, and Passivation of Stainless Steel Parts, Equipment, and Systems.
- p. A384/A384M, Standard Practice for Safeguarding Against Warpage and Distortion During Hot-Dip Galvanizing of Steel Assemblies.
- q. A385/A385M, Standard Practice for Providing High-Quality Zinc Coatings (Hot-Dip).
- r. A489, Standard Specification for Carbon Steel Lifting Eyes.
- s. A500/A500M, Standard Specification for Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes.
- t. A501, Standard Specification for Hot-Formed Welded and Seamless Carbon Steel Structural Tubing.
- u. A563, Standard Specification for Carbon and Alloy Steel Nuts.
- v. A653/A653M, Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process.
- w. A780/A780, Standard Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings.
- x. A786/A786M, Standard Specification for Hot-Rolled Carbon, Low-Alloy, High-Strength Low-Alloy, and Alloy Steel Floor Plates.
- y. A793, Standard Specification for Rolled Floor Plate, Stainless Steel.
- z. A967, Standard Specification for Chemical Passivation Treatments for Stainless Steel Parts.
- aa. A992/A992M, Standard Specification for Structural Steel Shapes.
- bb. A1085, Standard Specification for Cold-Formed Welded Carbon Steel Hollow Structural Sections (HSS).
- cc. B209, Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate.
- dd. B308/B308M, Standard Specification for Aluminum-Alloy 6061-T6 Standard Structural Profiles.
- ee. B429/B429M, Standard Specification for Aluminum-Alloy Extruded Structural Pipe and Tube.
- ff. B632/B632M, Standard Specification for Aluminum-Alloy Rolled Tread Plate.
- gg. C881/C881M, Standard Specification for Epoxy-Resin-Base Bonding Systems for Concrete.

- hh. D1056, Standard Specification for Flexible Cellular Materials - Sponge or Expanded Rubber.
 - ii. F436, Standard Specification for Hardened Steel Washers.
 - jj. F468, Standard Specification for Nonferrous Bolts, Hex Cap Screws, and Studs for General Use.
 - kk. F593, Standard Specification for Stainless Steel Bolts, Hex Cap Screws, and Studs.
 - ll. F594, Standard Specification for Stainless Steel Nuts.
 - mm. F844, Standard Specification for Washers, Steel, Plain (Flat), Unhardened for General Use.
 - nn. F1554, Standard Specification for Anchor Bolts, Steel, 36, 55, and 105-ksi Yield Strength.
9. NSF International (NSF): 61, Drinking Water System Components—Health Effects.
 10. Occupational Safety and Health Administration (OSHA):
 - a. 29 CFR 1910.23, Ladders.
 - b. 29 CFR 1910.29, Fall Protection Systems and Falling Object Protection - Criteria and Practices.
 - c. 29 CFR 1926.105, Safety Nets.
 - d. 29 CFR 1926.502, Fall Protection Systems Criteria and Practices.
 11. Specialty Steel Industry of North America (SSINA):
 - a. Specifications for Stainless Steel.
 - b. Design Guidelines for the Selection and Use of Stainless Steel.
 - c. Stainless Steel Fabrication.
 - d. Stainless Steel Fasteners.

1.02 DEFINITIONS

- A. Anchor Bolt: Cast-in-place anchor; concrete or masonry.
- B. Corrosive Area: Containment area or area exposed to delivery, storage, transfer, or use of chemicals.
- C. Exterior Area: Location not protected from weather by building or other enclosed structure.
- D. Interior Dry Area: Location inside building or structure where floor is not subject to liquid spills or washdown, nor where wall or roof slab is common to a water-holding or earth-retaining structure.
- E. Interior Wet Area: Location inside building or structure where floor is sloped to floor drains or gutters and is subject to liquid spills or washdown, or where wall, floor, or roof slab is common to a water-holding or earth-retaining structure.
- F. Submerged: Location at or below top of wall of open water-holding structure, such as basin or channel, or wall, ceiling or floor surface inside a covered

water-holding structure, or exterior belowgrade wall or roof surface of water-holding structure, open or covered.

1.03 SUBMITTALS

A. Action Submittals:

1. Shop Drawings: Metal fabrications, including welding and fastener information.

B. Informational Submittals: Passivation method for stainless steel members.

1.04 QUALITY ASSURANCE

A. Qualifications:

1. Galvanized Coating Applicator: Company specializing in hot-dip galvanizing after fabrication and following procedures of Quality Assurance Manual of the American Galvanizers Association.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Insofar as practical, factory assemble specified items. Package assemblies, which have to be shipped unassembled to protect materials from damage and tag to facilitate identification and field assembly.

B. Package stainless steel items to provide protection from carbon impregnation.

C. Protect painted coatings and hot-dip galvanized finishes from damage as a result of metal banding and rough handling. Use padded slings and straps.

D. Store fabricated items in dry area, not in direct contact with ground.

PART 2 PRODUCTS

2.01 GENERAL

A. For hot-dip galvanized steel that is exposed to view and does not receive paint, limit the combined phosphorus and silicon content to 0.04 percent. For steels that require a minimum of 0.15 percent silicon (such as plates over 1.5 inches thick for ASTM A36/A36M steel), limit maximum silicon content to 0.21 percent and phosphorous content to 0.03 percent.

B. Unless otherwise indicated, meet the following requirements:

| Item | ASTM Reference |
|---|---|
| Steel Wide Flange Shapes | A992/992M |
| Other Steel Shapes and Plates | A36/A36M or A572/A572M, Grade 50 or A992/A992M for other steel shapes |
| Steel Pipe | A500, Grade B |
| Hollow Structural Sections (HSS) | A500/A500M, Grade C |
| Aluminum: | |
| Aluminum Plates | B209, Alloy 6061-T6 |
| Aluminum Structural Shapes | B308/B308M, Alloy 6061-T6 |
| Stainless Steel: | |
| Bars and Angles | A276, AISI Type 316 (316L for welded connections) |
| Shapes | A276, AISI Type 304 (304L for welded connections) |
| Steel Plate, Sheet, and Strip | A240/A240M, AISI Type 316 (316L for welded connections) |
| Bolts, Threaded Rods, Anchor Bolts, and Anchor Studs | F593, AISI Type 316, Group 2, Condition SH |
| Nuts | F594, AISI Type 316, Condition CW |
| Steel Bolts and Nuts: | |
| Carbon Steel | A307 bolts, with A563 nuts |
| High-Strength | A325, Type 1 bolts, with A563 nuts |
| Anchor Bolts and Rods | F1554, Grade 36 |
| Eyebolts | A489 |
| Threaded Rods | A36/A36M |
| Flat Washers (Unhardened) | F844 |
| Flat and Beveled Washers (Hardened) | F436 |
| Thrust Ties for Steel Pipe: | |
| Threaded Rods | A193/A193M, Grade B7 |
| Nuts | A194/A194M, Grade 2H |

| Item | ASTM Reference |
|-------------------------|------------------------------------|
| Plate | A283/A283M, Grade D |
| Welded Anchor Studs | A108, Grades C-1010 through C-1020 |
| Aluminum Bolts and Nuts | F468, Alloy 2024-T4 |
| Titanium Bolts and Nuts | F468, Titanium Grade 2 |
| Cast Iron | A48/A48M, Class 35 |

- C. Bolts, Washers, and Nuts: Use stainless steel, titanium, hot-dip galvanized steel, zinc-plated steel, and aluminum material types as indicated in Fastener Schedule at end of this section.

2.02 ANCHOR BOLTS AND ANCHOR BOLT SLEEVES

A. Cast-In-Place Anchor Bolts:

- 1. Headed type, unless otherwise shown on Drawings.
- 2. Material type and protective coating as shown in Fastener Schedule at end of this section.

B. Anchor Bolt Sleeves:

- 1. Plastic:
 - a. Single unit construction with corrugated sleeve.
 - b. Top of sleeve shall be self-threading to provide adjustment of threaded anchor bolt projection.
 - c. Material: High-density polyethylene.
- 2. Fabricated Steel: ASTM A36/A36M.

2.03 POST-INSTALLED CONCRETE AND MASONRY ANCHORS

- A. See Section 05 05 19, Post-Installed Anchors.

2.04 LADDER SAFETY SYSTEM

A. General:

- 1. Conform to ALI A14.3 and OSHA CFR Part 1910.29.
- 2. Ladder safety system and support system shall be capable of withstanding, without failure, a drop test consisting of an 18-inch drop of a 500-pound weight.
- 3. Material: Stainless steel, AISI Type 316.

B. Components and Accessories:

1. Main Components: Carrier or climbing rail, dismount extension rail at top, sleeve or trolley, connectors, and body harness.
2. Ladder rung clamps with stainless steel, AISI Type 316, mounting brackets and hardware.
3. Furnish additional accessories required to provide complete system for each ladder.
4. Furnish pivot section at platforms and landings.
5. Furnish a total of two body harnesses for the Project.

C. Manufacturers and Products:

1. Miller by Honeywell, Franklin, PA; Miller Saf-T-Climb.
2. TS Products, Cambridge, Ontario, Canada; TS Safety Rail System.
3. FrenchCreek Fall Safety, Franklin, PA; Rigid Rail Climbing System.

2.05 ACCESSORIES

A. Antiseizing Lubricant for Stainless Steel Threaded Connections:

1. Suitable for potable water supply.
2. Resists washout.
3. Manufacturers and Products:
 - a. Bostik, Middleton, MA; Neverseez.
 - b. Saf-T-Eze Div., STL Corp., Lombard, IL; Anti-Seize.

2.06 FABRICATION

A. General:

1. Finish exposed surfaces smooth, sharp, and to well-defined lines.
2. Furnish necessary rabbets, lugs, and brackets so work can be assembled in neat, substantial manner.
3. Conceal fastenings where practical; where exposed, flush countersink.
4. Drill metalwork and countersink holes as required for attaching hardware or other materials.
5. Grind cut edges smooth and straight. Round sharp edges to small uniform radius. Grind burrs, jagged edges, and surface defects smooth.
6. Fit and assemble in largest practical sections for delivery to Site.

B. Materials:

1. Use steel shapes, unless otherwise noted.
2. Steel to be hot-dip galvanized: Limit silicon content to less than 0.04 percent or to between 0.15 percent and 0.25 percent.
3. Fabricate aluminum in accordance with AA Specifications for Aluminum Structures—Allowable Stress Design.

C. Welding:

1. Weld connections and grind exposed welds smooth. When required to be watertight, make welds continuous.
2. Welded fabrications shall be free from twisting or distortion caused by improper welding techniques.
3. Steel: Meet fabrication requirements of AWS D1.1/D1.1M, Section 5.
4. Aluminum: Meet requirements of AWS D1.2/D1.2M.
5. Stainless Steel: Meet requirements of AWS D1.6/D1.6M.
6. Complete welding before applying finish.

D. Galvanizing:

1. Fabricate steel to be galvanized in accordance with ASTM A143/A143M, ASTM A384/A384M, and ASTM A385/A385M. Avoid fabrication techniques that could cause distortion or embrittlement of the steel.
2. Provide venting and drain holes for tubular members and fabricated assemblies in accordance with ASTM A385/A385M.
3. Remove welding slag, splatter, burrs, grease, oil, paint, lacquer, and other deleterious material prior to delivery for galvanizing.
4. Remove by blast cleaning or other methods surface contaminants and coatings not removable by normal chemical cleaning process in the galvanizing operation.
5. Hot-dip galvanize steel members, fabrications, and assemblies after fabrication in accordance with ASTM A123/A123M.
6. Hot-dip galvanize bolts, nuts, washers, and hardware components in accordance with ASTM A153/A153M. Oversize holes to allow for zinc alloy growth. Shop assemble bolts and nuts.
7. Galvanized steel sheets in accordance with ASTM A653/A653M.
8. Galvanize components of bolted assemblies separately before assembly. Galvanizing of tapped holes is not required.

E. Electrolytic Protection: Coat surfaces of aluminum fabricated items to be in direct contact with concrete, grout, or masonry, and dissimilar metals where in contact with one another with one coat, 10 MDFT, of bituminous paint unless indicated otherwise.

F. Fitting: Where movement of fabrications is required or shown, cut, fit, and align items for smooth operation. Make corners square and opposite sides parallel.

G. Accessories: Furnish as required for a complete installation. Fasten by welding or with stainless steel bolts or screws.

2.07 SOURCE QUALITY CONTROL

- A. Visually inspect all fabrication welds and correct deficiencies.
 - 1. Steel: AWS D1.1/D1.1M, Section 6 and Table 6.1, Visual Inspection Acceptance Criteria.
 - 2. Aluminum: AWS D1.2/D1.2M.
 - 3. Stainless Steel: AWS D1.6/D1.6M.

PART 3 EXECUTION

3.01 INSTALLATION OF METAL FABRICATIONS

- A. General:
 - 1. Install metal fabrications plumb and level, accurately fitted, free from distortion or defects.
 - 2. Install rigid, substantial, and neat in appearance.
 - 3. Install manufactured products in accordance with manufacturer's recommendations.
 - 4. Obtain Engineer approval prior to field cutting steel members or making adjustments not scheduled.
- B. Aluminum:
 - 1. Do not remove mill markings from concealed surfaces.
 - 2. Remove inked or painted identification marks on exposed surfaces not otherwise coated after installed material has been inspected and approved.
 - 3. Fabrication, mechanical connections, and welded construction shall be in accordance with the AA Aluminum Design Manual.

3.02 CAST-IN-PLACE ANCHOR BOLTS

- A. Locate and hold anchor bolts in place with templates at time concrete is placed.
- B. Use anchor bolt sleeves for location adjustment and provide two nuts and one washer per bolt of same material as bolt.
- C. Minimum Bolt Size: 1/2-inch diameter by 12 inches long, unless otherwise shown.

3.03 LADDER SAFETY SYSTEM

- A. Provide where indicated in Specifications or on Drawings.
- B. Install in accordance with manufacturer's instructions. Install ladder safety system on far left side of ladder to maximize dismounting clearance at top of ladder.
- C. When installed to required height, ladder safety system shall be rigid and an integral part of the structure.

3.04 ELECTROLYTIC PROTECTION

- A. Aluminum and Galvanized Steel:
 - 1. Coat surfaces of aluminum fabricated items to be in direct contact with concrete, grout, or masonry, and dissimilar metals where in contact with one another with one coat, 10 MDFT, of bituminous paint unless indicated otherwise.
 - 2. Allow coating to dry before installation of the material.
 - 3. Protect coated surfaces during installation.
 - 4. Should coating become marred, prepare and touch up in accordance with paint manufacturer's written instructions.
- B. Stainless Steel:
 - 1. During handling and installation, take necessary precautions to prevent carbon impregnation of stainless steel members.
 - 2. After installation, visually inspect stainless steel surfaces for evidence of iron rust, oil, paint, and other forms of contamination.
 - 3. Remove contamination using cleaning and passivation methods in accordance with requirements of ASTM A380 and ASTM A967.
 - 4. Brushes used to remove foreign substances shall utilize only stainless steel or nonmetallic bristles.
 - 5. After treatment, visually inspect surfaces for compliance.

3.05 PAINTING

- A. Repair of Damaged Hot-Dip Galvanized Coating:
 - 1. Conform to ASTM A780/A780M.
 - 2. For minor repairs at abraded areas, use sprayed zinc conforming to ASTM A780/A780M.
 - 3. For flame cut or welded areas, use zinc-based solder, or zinc sticks, conforming to ASTM A780/A780M.
 - 4. Use magnetic gauge to determine thickness is equal to or greater than base galvanized coating.

3.06 FASTENER SCHEDULE

A. Unless indicated otherwise on Drawings, provide fasteners as follows:

| Service Use and Location | Product | Remarks |
|---|---|---|
| 1. Anchor Bolts Cast Into Concrete for Equipment Bases, Structural Steel, and Metal Fabrications and Castings | | |
| Interior Dry Areas | Headed anchor bolts, anchor material type to match material being anchored (for example, stainless steel anchor bolts to anchor stainless steel equipment, zinc-plated anchor bolts to anchor painted equipment, galvanized anchor bolts to anchor galvanized equipment). Use titanium headed anchor bolts to anchor FRP equipment. | |
| Exterior and Interior Wet Areas | Titanium headed anchor bolts | |
| Submerged and Corrosive Areas | Titanium headed anchor bolts with fusion bonded coating | Fusion bonded coating: 100% solids, thermosetting, fusion bonded, dry powder epoxy, suitable for intended service |
| 2. Post-Installed Anchors: See Section 05 05 19, Post-Installed Anchors | | |

| Service Use and Location | Product | Remarks |
|---|---|--|
| 3. Connections for Structural Steel Framing | | |
| Exterior and Interior Wet and Dry Areas | High-strength steel bolted connections | Use hot-dipped galvanized high-strength bolted connections for galvanized steel framing members. |
| 4. Connections for Steel Fabrications | | |
| Exterior and Interior Wet and Dry Areas | Stainless steel bolted connections | |
| 5. Connections of Aluminum Components | | |
| Submerged, Exterior and Interior Wet and Dry Areas | Stainless steel bolted connections, unless otherwise specified with equipment | |
| 6. All Others | | |
| Exterior and Interior Wet and Dry Areas | Stainless steel fasteners | |

B. Antiseizing Lubricant: Use on stainless steel threads.

END OF SECTION

SECTION 06 82 00
GLASS-FIBER-REINFORCED PLASTIC

PART 1 GENERAL

1.01 REFERENCES

- A. The following is a list of standards which may be referenced in this section:
1. ASTM International (ASTM):
 - a. C177, Standard Test Method for Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Guarded Hot-Plate Apparatus.
 - b. D570, Standard Test Method for Water Absorption of Plastics.
 - c. D635, Standard Test Method for Rate of Burning and/or Extent and Time of Burning Plastics in a Horizontal Position.
 - d. D638, Standard Test Method for Tensile Properties of Plastics.
 - e. D695, Standard Test Method for Compressive Properties of Rigid Plastics.
 - f. D696, Standard Test Method for Coefficient of Linear Thermal Expansion of Plastics Between -30 Degrees C and 30 Degrees C.
 - g. D790, Standard Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials.
 - h. D792, Standard Test Methods for Density and Specific Gravity (Relative Density) by Plastics Displacement.
 - i. D2344, Standard Test Method for Apparent Interlaminar Shear Strength of Parallel Fiber Composites by Short-Beam Method.
 - j. D2583, Standard Test Method for Indentation Hardness of Rigid Plastics by Means of a Barcol Impressor.
 - k. E84, Standard Test Method for Surface Burning Characteristics of Building Materials.
 2. International Code Council (ICC): International Building Code (IBC).
 3. Occupational Safety and Health Act (OSHA):
 - a. 29 CFR 1910, Code of Federal Regulations.
 - b. 29 CFR 1910.29, Fall Protection Systems and Falling Object Protection - Criteria and Practices.
 4. Underwriters' Laboratories, Inc. (UL): 94, UL Standard for Safety Test for Flammability of Plastic Materials for Parts in Devices and Appliances.

1.02 DESIGN REQUIREMENTS

- A. This section contains components and connectors that require Contractor design.

1.03 SUBMITTALS

A. Action Submittals:

1. Shop Drawings:
 - a. Product Data: Catalog information and catalog cuts showing materials, colors, resins, and load tables showing load, span, and deflection; include manufacturer's specifications.
 - b. Grating: Show dimensions, weight, size, and location of connections to adjacent grating, supports, and other Work.
 - c. Grating Supports: Show dimensions, weight, size, location, and anchorage to supporting structure.
 - d. Platforms, Handrails, Ladders, and Support Structures:
 - 1) Show dimensions, weight, size, and location of connections to adjacent supports and other Work.
 - 2) Structural calculations for platforms, ladders, handrails, and other fabrications shown.

B. Informational Submittals:

1. Handling and storage requirements.
2. Manufacturer's installation instructions.
3. Factory test reports for physical properties of product.
 - a. Test data for handrails and supports may supplement load calculations providing data covers the complete system, including anchorage.
 - b. Test data for all components showing load and deflection due to load, in enough detail to prove handrail is strong enough and satisfies national, state, local standards, regulations, code requirements, and OSHA 29 CFR 1910, using design loads specified.
 - c. Include test data for the following:
 - 1) Railing and post connections.
 - 2) Post and base connections.
4. Manufacturer's Certification of Compliance for specified products.
5. Fabricator's qualification experience.
6. Manufacturer's qualification experience.
7. Independent laboratory test report, dated within 2 years of submittal date of fire retardant testing conducted on exact type of grating proposed (not a resin test report).

1.04 QUALIFICATIONS

- A. Designer: Calculations required for Contractor design shall be stamped by a registered engineer, licensed in state where Project will be constructed.
- B. Fabricator: Minimum of 5 years' experience.

- C. Manufacturer: Minimum of 5 years' experience in manufacturing of products meeting these specifications.

1.05 DELIVERY, STORAGE, AND HANDLING

- A. Preparation for Shipment:
 - 1. Insofar as is practical, factory assemble items provided hereunder.
 - 2. Ladders shall be shipped fully shop-fabricated and assembled.
 - 3. Package and clearly tag parts and assemblies that are of necessity shipped unassembled in a manner that will protect materials from damage and facilitate identification and final assembly in field.
- B. Storage and Handling: In accordance with manufacturer's recommendations and in such a manner as to prevent damage of any kind, including overexposure to sunlight.

PART 2 PRODUCTS

2.01 GENERAL

- A. Like Items of Materials: Where possible, provide end products of one manufacturer in order to achieve standardization for appearance, maintenance, and replacement.
- B. Unless otherwise specified, all products shall be manufactured by a pultruded process using vinyl ester resin.
- C. Products shall be manufactured with ultra-violet (UV) inhibitor additives.
- D. Exterior surfaces shall have a synthetic surface veil covering.
- E. Furnish molded products as an option where permitted by specifications.
- F. Fire Retardance:
 - 1. Flame spread shall be less than 25 as measured by ASTM E84.
 - 2. Include combinations of aluminum trihydrate, halogen, and antimony trioxide, where required to meet fire retardance, in the resin system.
 - 3. Meet self-extinguishing requirements of ASTM D635.
- G. Color pigment shall be dispersed in resin system.
- H. Fabricate FRP products exposed to outdoor conditions with an additional 1-mil thick UV coating to shield product from UV light.
- I. All cut ends, holes, and abrasions of FRP shapes shall be sealed with resin to prevent intrusion of moisture.

2.02 GRATING AND STAIR TREADS

A. General:

1. 100 psf minimum, unless otherwise shown.
2. Maximum Deflection: 1/4 inch, unless otherwise shown.

B. Molded Type:

1. Nonskid grit affixed to top of bar surface or a concave, meniscus top to all bars, providing skid resistance.
2. Load bars in both directions with equal stiffness.
3. Square mesh with 1-1/2-inch maximum spacing.

C. Pultruded Type:

1. Main bars joined by cross bars secured in holes drilled in main bars.
2. Cross bars with 6-inch maximum spacing shall mechanically lock main bars in position such that they prevent movement.
3. Intersections: Bond using adhesive as corrosive-resistant as pultrusion resin.
4. Main Bar Ends: Minimum bearing support width of 1-1/2 inches.
5. Skid-Resistant Surface: Grit adhesively bonded, manufacturer's standard.
6. Provide extra stiffness around openings.

D. Hold-Down Clamps: Type 316 stainless steel.

E. Bolts and Connectors:

1. Corrosion-resistant FRP or Type 316 stainless steel.
2. Size and strength to meet IBC requirements.

F. Fabrications:

1. Field measure areas to receive grating. Verify dimensions of new fabricated supports and fabricate to dimension required for specified clearances.
2. Section Length: Sufficient to prevent it falling through clear opening when oriented in span direction when one end is touching either concrete or vertical leg of grating support.

G. Manufacturers:

1. Fibergrate Composite Structures, Inc., Addison, TX.
2. IKG/Borden, Clark, NJ.

3. Strongwell Corp., Bristol Division, Bristol, VA or Chatfield Division, Chatfield, MN.
4. International Grating, Inc., Houston, TX.

2.03 STRUCTURAL PLATFORMS

A. Deflection and Safety Factors:

1. Deflection Criteria: Not to exceed $L/360$.
2. Safety Factors: Minimum ratios of ultimate stress to allowable static service stress:
 - a. Flexural Members: 2.5.
 - b. Compression Members: 3.0.
 - c. Shear: 3.0.
 - d. Connections: 4.0.
3. Minimum design safety factors for dynamic or impact loads shall be twice the values for static service loads.

B. Loads:

1. 100 psf uniform live load over platform.
2. Static and dynamic loads for equipment shown.

C. Glass fiber reinforced polyester or vinyl ester resin matrix, approximately 50 percent resin-to-glass ratio.

D. Continuous glass strand rovings shall be used internally for longitudinal strength.

E. Continuous strand glass mats shall be used internally for transverse strength.

F. Material Properties of FRP Structural Shapes:

| Minimum Ultimate Coupon Properties (UN) | | |
|--|--------------------|--------------|
| Material Properties | Test Method | Units |
| Pultruded Fiberglass Structural Shapes | | |
| Ultimate tensile stress in longitudinal direction, psi (MPa) | ASTM D638 | 30,000 (207) |
| Ultimate compressive stress in longitudinal direction, psi (MPa) | ASTM D695 | 30,000 (207) |

| Minimum Ultimate Coupon Properties (UN) | | |
|--|--------------------|--------------------------------|
| Material Properties | Test Method | Units |
| Ultimate flexural stress in longitudinal direction, psi (MPa) | ASTM D790 | 30,000 (207) |
| Ultimate short beam shear in longitudinal direction, psi (MPa) | ASTM D2344 | 4,500 (31) |
| Ultimate tensile stress in transverse direction, psi (MPa) | ASTM D638 | 7,000 (48) |
| Ultimate compressive stress in transverse direction, psi (MPa) | ASTM D695 | 15,000 (103) |
| Ultimate flexural stress in transverse direction, psi (MPa) | ASTM D790 | 10,000 (69) |
| Density (lb/in. ³) (kg/mm ³) | ASTM D792 | 0.060-0.070 (0.00166-00194) |
| Water absorption (25-hr immersion) | ASTM D570 | 0.60 max, % by weight |
| Barcol hardness | ASTM D2583 | 45 |
| Coefficient of thermal expansion 10 ⁻⁶ in./in./° C | ASTM D696 | |
| Expansion, LW10 ⁻⁶ in./in./° F | | 4.4 |
| Thermal conductivity, Btu-in./ft ² /hr/° F | ASTM C177 | |
| Flame-Retardant Properties | | |
| Flammability test | ASTM D635 | Self-extinguishing |
| Surface burning characteristics | ASTM E84 | 25 maximum |
| Flammability class | UL 94 | VO |
| Temperature index | UL 94 | 130 C |

G. Manufacturers and Designers:

1. Strongwell Corp., Bristol, VA.
2. Fibergrate Composite Structures, Inc., Addison, TX.

2.04 HANDRAIL

A. Structural Criteria:

1. Deflection: No permanent set in any member or connection when tested to design load.
2. Apply load to produce maximum stress and deflection in each of the respective components.
3. Top Rail and Posts of Handrails: Capable of withstanding the following load cases applied with a safety factor of 1.33:
 - a. Concentrated load of 200 pounds applied at any point and in any direction on the top rail in accordance with ICC IBC.
 - b. Uniform load on the top rail of 50 pounds per linear foot applied in any direction in accordance with ICC IBC.
 - c. Concentrated load need not be assumed to act concurrently with uniform loads in accordance with ICC IBC.
4. Mid-Rails with Corner Returns: Capable of withstanding a 300-pound concentrated vertical load applied at any point or direction without damage and loosening of fittings or attachment hardware, applied with a safety factor of 1.33.
5. Connections, Mounts, Bases: Withstand all handrail loads without permanent set and with a safety factor of at least 1.65 against failure.

B. Thermal Movement:

1. Allow for maximum range of ambient temperature change (difference between high or low and installation temperature).
2. Base design on actual surface temperatures of materials due to both solar heat gain and night time sky heat loss.
3. Temperature Change Range: 70 degrees F, ambient; 100 degrees F, material surfaces.

C. Rails and Posts:

1. 2-inch nominal square or round tubing posts.
2. 1-3/4- or 2-inch nominal round or square rails.
3. Maximum Post Spacing: 5 feet.
4. Clearance between Rails: Meet ICC IBC requirements.

D. Kickplates: Corrugated, 4 inches by 1/2 inch by 0.125 inch thick or 4 inches by 9/16 inch thick. Provide kickplate taller than 4 inches where indicated on Drawings.

E. Kickplate Connectors and Splices: Continuous with provision for expansion and contraction without distortion or buckling.

F. Connections, Mounts, Bases: Fiberglass or Type 316 stainless steel.

G. Pultruded Parts:

| Minimum Mechanical Properties | Test Method | Values |
|--------------------------------------|--------------------|---|
| Tensile Stress | ASTM D638 | 30,000 psi |
| Tensile Modulus | ASTM D638 | 2.5 x 10 ⁶ psi |
| Compressive Stress | ASTM D695 | 30,000 psi |
| Compressive Modulus | ASTM D695 | 2.5 x 10 ⁶ psi |
| Flexural Stress | ASTM D790 | 30,000 psi |
| Flexural Modulus | ASTM D790 | 1.6 x 10 ⁶ psi |
| Shear Stress | ASTM D2344 | 4,500 psi |
| Density | ASTM D792 | 0.060-0.070 lbs/in. ³ |
| 24-Hour Water Absorption | ASTM D570 | 0.6% max. |
| Coefficient of Thermal Expansion | ASTM D696 | 4.4 x 10 ⁻⁶ in./in./degree F |
| Flexural Stress | Full Section | 36,000 psi |
| Flexural Modulus | Full Section | 3.7 x 10 ⁶ psi |

H. Manufacturers:

1. Strongwell Corp., Bristol, VA.
2. Fibergrate Composite Structures, Inc., Addison, TX.

2.05 LADDERS

A. Ladder Criteria:

1. Capable of supporting a 250-pound concentrated load plus 30 percent impact at midspan of rung.
2. Side Rails: 1-3/4-inch square tubes, 0.25 inch thick.
3. Rungs: Minimum 1-inch diameter thermal cure rod with pigmented epoxy, nonskid grit surface, or 1-1/4-inch minimum diameter pultruded, fluted, nonslip surface of vinyl ester resin.
4. Provide ladder safety system as specified in Section 05 50 00, Metal Fabrications, for the ladders to be provided for the new FRP tanks in the Sodium Hypochlorite Facility. Ladders with ladder safety system shall be capable of withstanding, without failure, a drop test consisting of an

18-inch drop of a 500-pound weight in accordance with OSHA CFR Part 1910.29.

B. Manufacturers:

1. Strongwell Corp., Bristol, VA.
2. Fibergrate Composite Structures, Inc., Addison, TX.

PART 3 EXECUTION

3.01 GENERAL

- A. Install in accordance with manufacturer's written instructions.
- B. Install plumb or level, rigid and neat, as applicable.
- C. Furnish fasteners and anchorages for complete installation.
- D. Seal field cut holes, edges, and abrasions with catalyzed resin compatible with original resin.

3.02 GRATING

- A. Anchor grating securely to supports to prevent displacement.
- B. Install each grating section such that it is easily removable.
- C. Clearance (Grating to Vertical Surfaces): 1/4 inch (plus or minus 1/8-inch tolerance).

3.03 STRUCTURAL SHAPES

- A. Connect parts with approved connectors meeting manufacturer's design requirements and with corrosion resistance equal to structural shapes.
- B. Provide supports and bracings required to comply with applicable codes and design requirements.

3.04 LADDERS

- A. For ladders with ladder safety system, coordinate attachment of ladder safety system to ladder with ladder safety system manufacturer. Install ladder safety system on far left side of ladder to maximize dismounting clearance at top of ladder.

END OF SECTION

**SECTION 09 97 00
SPECIAL COATINGS**

PART 1 GENERAL

1.01 REFERENCES

- A. The following is a list of standards which may be referenced in this section:
1. The Society for Protective Coatings (SSPC):
 - a. PA 2, Measurement of Dry Coating Thickness with Magnetic Gages.
 - b. PA 3, Guide to Safety in Paint Applications.
 - c. SP 1, Solvent Cleaning.
 - d. SP 2, Hand Tool Cleaning.
 - e. SP 3, Power Tool Cleaning.
 - f. SP 5, White Metal Blast Cleaning.
 - g. SP 6, Commercial Blast Cleaning.
 - h. SP 7, Joint Surface Preparation Standard Brush-Off Blast Cleaning.
 - i. SP 10, Near-White Blast Cleaning.
 - j. SP 11, Power Tool Cleaning to Bare Metal.
 - k. SP 12, Surface Preparation and Cleaning of Metals Water jetting Prior to Recoating.
 - l. SP 13, Surface Preparation of Concrete.
 - m. Guide 15, Field Methods for Retrieval and Analysis of Soluble Salts on Steel and Other Nonporous Substrates.
 2. ASTM International (ASTIM)
 - a. D-638, Standard Test Method for Tensile Properties of Plastics.
 - b. C-580, Standard Test Method for Flexural Strength and Modulus of Elasticity of Chemical-Resistant Mortars, Grouts, Monolithic Surfacing, and Polymer Concretes.
 - c. D-2240, Rubber Hardness Testing.
 - d. D-4541, Standard Test Method for Pull-Off Strength of Coatings Using Portable Adhesion Testers
 - e. D-4060, Taber Abrasion Testing
 - f. C-531, Standard Test Method for Linear Shrinkage and Coefficient of Thermal Expansion

1.02 SUBMITTALS

- A. Action Submittals:
1. Product Data: Submit manufacturer's technical data, installation instructions, and general recommendations for each resinous lining material required. Include certification indicating compliance of materials with requirements.

2. Samples: Submit, for verification purposes, 4-inch square samples of each type of resinous lining required, applied to a rigid backing, in color and finish indicated.
 - a. For initial selection of colors and finishes, submit manufacturer's color charts showing full range of colors and finishes available.

B. Informational Submittals:

1. Prior to delivery provide manufacturer's instructions for materials requiring special shipping, storage, or handling requirements.
2. Manufacturer's printed installation instructions.
3. Manufacturer's Certificate of Compliance, in accordance with Section 01 43 33, Manufacturers' Field Services.
4. Manufacturer's Certificate of Proper Installation, in accordance with Section 01 43 33, Manufacturers' Field Services.

1.03 QUALITY ASSURANCE

- A. Nationally recognized manufacturers of coatings who are regularly engaged in the production of such materials for essentially identical service conditions.
- B. Minimum of 5 years' verifiable experience in manufacture of specified product.

1.04 DELIVERY, STORAGE, AND HANDLING

- A. Material shall be delivered to job site and checked by lining contractor for completeness and shipping damage prior to job start.
- B. All materials used shall be factory pre-weighed and pre-packaged in single, easy to manage batches to eliminate on-site mixing errors. No on-site weighing or volumetric measurements allowed.
- C. Material shall be stored in a dry, enclosed area protected from exposure to moisture. Temperature of storage area shall be maintained between 50 to 75 degrees F.

1.05 SPECIAL GUARANTEE

- A. Provide manufacturer's extended guarantee or warranty, with Owner named as beneficiary, in writing, as special guarantee. Special guarantee shall provide for correction, or at the option of the Owner, removal and replacement of coatings or lining found defective during a period of one year after the date of Substantial Completion. Duties and obligations for correction or removal and replacement of defective Work shall be as specified in the General Conditions.

PART 2 PRODUCTS

2.01 RESINOUS SPECIAL COATING

- A. Nominal 60 mil/1.5 mm thick high performance epoxy hybrid system comprised of a penetrating two-component epoxy primer, a two-component, high performance epoxy hybrid, resin rich basecoat, engineering fabric, a penetrating, two-component high performance epoxy hybrid saturant, a three-component mortarcoat consisting of high performance epoxy hybrid resin, curing agent and finely divided mineral composite aggregate and a highly impermeable, mineral composite topcoat.
- B. Physical Properties:
 - 1. Tensile Strength: 11,000 psi (ASTM D638).
 - 2. Flexural Strength: 12,000 psi (ASTM C580).
 - 3. Hardness: 85-90 (ASTM D2240, Shore D).
 - 4. Bond Strength: greater than 400 psi (ASTM D4541).
 - 5. Abrasion Resistance: 0.12 gm max. weight loss (ASTM D4060, CS-17).
 - 6. Flexural Modulus of Elasticity: 6.0 x 10⁵ psi (ASTM C580).
 - 7. Thermal Coefficient of Linear Expansion: 2.2 x 10⁻⁵ in./(in.deg C) (ASTM C531).
 - 8. Cure Rate: 24 hours for normal operations at 70 degrees F.
- C. Manufacturers and Products: Stonhard; Stonchem 556.

2.02 SERVICE CONDITIONS

- A. Coating suitable for contact/exposure to 15 percent sodium hypochlorite.

PART 3 EXECUTION

3.01 GENERAL

- A. Provide Engineer minimum 7 days' advance notice to start field surface preparation work and coating application work.
- B. Schedule inspection of cleaned surfaces and all coats prior to succeeding coat in advance with Engineer.
- C. Coating manufacturer to repair existing cracks in concrete substrates prior to installing coating. Any crack repairs not covered by the coating manufacturer's work shall be repaired by Contractor using epoxy injection as specified in Section 03 64 23, Epoxy Resin Injection Grouting. Epoxy-injected cracks shall be finished by Contractor to be flush with adjacent concrete surfaces.

3.02 EXAMINATION

- A. Surface Preparation Verification: Inspect and provide substrate surfaces prepared in accordance with these Specifications and the manufacturer's installation requirements.

3.03 PREPARATION

- A. Prepare surface in accordance with the manufacturer's installation requirements.

3.04 TESTS AND INSPECTION

- A. In accordance with Section 01 91 14, Equipment Testing and Facility Startup.
- B. Thickness and Continuity Testing: Measure coating thickness specified in mils with a magnetic type, dry film thickness gauge, in accordance with SSPC PA 2. Check each coat for correct millage. Do not make measurement before a minimum of 8 hours after application of coating.

3.05 MANUFACTURER'S SERVICES

- A. Coating manufacturer's representative shall be present at Site as follows:
 - 1. On first day of application of any coating system.
 - 2. A minimum of 2 additional Site inspection visits, each for a minimum of 4 hours, in order to provide Manufacturer's Certificate of Proper Installation.
 - 3. As required to resolve field problems attributable to or associated with manufacturer's product.
 - 4. To verify full cure of coating prior to coated surfaces being placed into immersion service.

3.06 CLEANING/ADJUSTING

- A. Remove paint spots, oil, or stains upon adjacent surfaces and floors and leave entire job clean.

END OF SECTION

**SECTION 10 14 00
SIGNAGE**

PART 1 GENERAL

1.01 REFERENCES

- A. The following is a list of standards that may be referenced in this section:
1. American Society of Mechanical Engineers (ASME): A13.1, Scheme for the Identification of Piping Systems.
 2. International Code Council (ICC):
 - a. A117.1-2009, Accessible and Usable Buildings and Facilities.
 - b. International Fire Code (IFC): Chapter 27, Hazardous Materials-General Provisions.
 3. National Fire Protection Association (NFPA):
 - a. 704, Standard System for the Identification of the Hazards of Materials for Emergency Response.
 - b. HAZ-01, Fire Protection Guide to Hazardous Materials.
 4. Occupational Safety and Health Act (OSHA).

1.02 SUBMITTALS

- A. Action Submittals:
1. Shop Drawings:
 - a. Drawings showing layouts for each label/tag, actual letter sizes and styles, and Project-specific mounting details.
 - 1) Provide a schedule or table with all label/ names for review by the Engineer.
 - b. Manufacturer's literature showing letter sizes and styles, sign materials, and standard mounting details.
 2. Anchorage and bracing data sheets and drawings as required by Section 01 88 15, Anchorage and Bracing.
- B. Informational Submittals: Manufacturer's installation instructions.

PART 2 PRODUCTS

2.01 IDENTIFICATION LABELS

- A. Pipe Labels:
1. Snap-on, reversible type with lettering and directional arrows, sized for outside diameter of pipe and insulation.
 2. Provided with ties or straps for pipes of 6 inches and over diameter.
 3. Designed to firmly grip pipe so labels remain fixed in vertical pipe runs.

4. Material: Heavy-duty vinyl or polyester, suitable for exterior use, long lasting, and resistance to sodium hypochlorite, moisture, grease, and oils.
5. Letters and Arrows: Black.
6. Color Field and Letter Height: Yellow background, meet ASME A13.1.
7. Message: Piping size and piping label name as indicated on Piping Schedule.
8. Manufacturers and Products:
 - a. Brady Signmark; B-915 BradySnap-On and Strap-On Pipe Markers.
 - b. Seton Identification Products; Ultra-mark Pipe Markers.
 - c. Or equal.

B. Equipment Labels:

1. Provide equipment labels for: Electric valve actuators, level elements/sensors, sump pumps, and other equipment with assigned tag numbers.
2. Letters: Black bold face, 3/4 inch minimum high.
3. Background: White.
4. Materials: Fiberglass with encased lettering.
5. Furnish 1-inch margin with holes at each end of label, for mounting. On fiberglass labels, furnish grommets at each hole.
6. Size:
 - a. 2 inches minimum and 3 inches maximum high, width as necessary to fit text.
 - b. Furnish same size base dimensions for all labels.
7. Message/Text on Label:
 - a. Equipment tag number.
 - b. Equipment name/description.
 - c. Manufacturer and Model.
 - d. Equipment size, capacity and/or rating.
8. Manufacturers:
 - a. Brady Signmark.
 - b. Seton Identification Products.
 - c. Or equal.

2.02 ANCILLARY MATERIALS

- A. Fasteners: Titanium screws or bolts of appropriate sizes.

PART 3 EXECUTION

3.01 INSTALLATION—GENERAL

- A. In accordance with manufacturer's recommendations.
- B. Mount securely, plumb, and level.

3.02 IDENTIFICATION LABELS

A. Pipe Labels:

1. Locate at connections to equipment, valves, or branching fittings at wall boundaries.
2. At intervals along piping not greater than 10 feet on center with at least one label applied to each exposed horizontal and vertical run of pipe.
3. At exposed piping not normally in view, such as above suspended ceilings and in closets and cabinets.
4. Supplementary Labels: Provide to Owner those listed on Piping Schedule that do not receive arrows.
5. Apply to pipe after painting in vicinity is complete, or as approved by Engineer.
6. Install in accordance with manufacturer's instructions.

B. Equipment Labels:

1. Locate and install on equipment or concrete equipment base.
2. Anchor to equipment or base for easy removal and replacement with ordinary hand tools.

END OF SECTION

SECTION 22 30 00
SUBMERSIBLE SUMP PUMP

PART 1 GENERAL

1.01 REFERENCES

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

1. American Society of Mechanical Engineer's (ASME).
2. ASTM International (ASTM):
 - a. A48/A48M, Standard Specification for Gray Iron Castings.
 - b. D4101, Standard Specification for Polypropylene Injection and Extrusion Materials.
3. International Code Council (ICC): International Plumbing Code (IPC).
4. National Electrical Code (NEC).
5. NSF International (NSF):
 - a. NSF/ANSI 61, Drinking Water System Components - Health Effects.
 - b. NSF/ANSI 372, Drinking Water System Components - Lead Content.
6. Underwriters Laboratories Inc. (UL).

1.02 SUBMITTALS

A. Action Submittals:

1. Manufacturer's product data.
2. Seismic anchorage and bracing drawings and cut sheets, as required by Section 01 88 15, Anchorage and Bracing.
3. Manufacturer's pump curve with specified operating point.
4. Product data confirming full compatibility with sodium hypochlorite.

B. Informational Submittals:

1. Seismic anchorage and bracing calculations as required by Section 01 88 15, Anchorage and Bracing.
2. Operation and Maintenance Manual as specified in Section 01 78 23, Operation and Maintenance Manuals.

1.03 WARRANTY

A. Provide manufacturer's extended warranty in writing with Owner named as beneficiary. Warranty shall provide for correction, or removal and replacement of products found defective during the stated period after date of Substantial Completion as specified in the General Conditions.

PART 2 PRODUCTS

2.01 SUBMERSIBLE CENTRIFUGAL SUMP PUMPS

A. Simplex, Submersible Sump Pump:

1. Description:
 - a. Type: simplex, chemical resistant, submersible sump pump.
 - b. Pump Suction Cover, Motor Housing and Upper Volute: glass-filled polyphenylene oxide (PPO).
 - c. Pump Base and Strainer: Glass-filled polyphenylene oxide (PPO).
 - d. Pump Cover: Resistant to sodium hypochlorite or provide sodium hypochlorite resistant coating on pump cover.
 - e. Hardware: Titanium.
 - f. Seals: FKM (Viton) Elastomers.
 - g. Impeller: Glass-filled PPO.
 - h. Discharge Flange: 1.25-inch NPT.
 - i. Motor: continuous-duty, built-in thermal overload protection with service factor of 1.10.
 - j. Shaft Seals: Tandem, mechanical type.
 - k. Shaft: Titanium.
 - l. Minimum bearing L10 life shall be 30,000 hours.
 - m. Power Cable Outer Jacket: Neoprene and sized in accordance with NEC standards.
 - n. Control Panel:
 - 1) Single phase control panel with mechanical float switches with:
 - a) NEMA 4X fiberglass enclosure.
 - b) Auxiliary contacts for alarming to SCADA.
 - c) Integral float switches.
 - d) NEMA Rated contractors.
 - e) Motor heat sensor connections.
 - f) Hand-off-auto and on-off selector switches.
 - g) Pump run lights.
 - h) Alarm light with silence push button.
 - 2) Circuit Breakers: Motor rated.
 - 3) Motor Starters: Magnetic with solid state overload protection device.
 - 4) Polypropylene-encapsulated mechanical float switch with neoprene outer jacket.
 - 5) Provide a 120 vac dry SPDT output contact for each of the following for status: RUN, FAIL, HIGH LEVEL.
 - 6) Control panel shall comply with Section 40 90 01, Instrumentation and Control for Process Systems.
2. Capacity: See data sheet at end of section.

3. Manufacturers:
 - a. BJM Pumps, LLC.
 - b. Tsurumi Manufacturing Co., Ltd.
 - c. Or-equal.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Install, arrange, and connect equipment as shown on Drawings and in accordance with manufacturer's recommendations.

3.02 FIELD QUALITY CONTROL

- A. Startup: In accordance with Section 01 91 14, Equipment Testing and Facility Startup.

3.03 SUPPLEMENTS

- A. Supplements listed below, following "End of Section," are a part of this Specification.
 1. Data Sheet: Simplex, Submersible Sump Pump.

END OF SECTION

| Simplex, Submersible Sump Pump | | | | | | |
|---------------------------------------|--------------------------------|----------------------------|-------------------------|--------------------------|----------------------------|-------------------------|
| Tag Number | Maximum Flow Rate (gpm) | Maximum Head (feet) | Motor (rated hp) | Motor Speed (rpm) | Power (volts/phase) | Manufacturer |
| NFF-PUMP-SUMP-04 | 46 | 27 | 0.4 | 3450 | 115V/1ph | Refer to specification. |

SECTION 26 05 02
BASIC ELECTRICAL REQUIREMENTS

PART 1 GENERAL

1.01 RELATED SECTIONS

- A. Requirements specified within this section apply to Division 26, Electrical. Work specified herein shall be performed as if specified in the individual sections.

1.02 REFERENCES

- A. The following is a list of standards which may be referenced in this section:
1. National Electrical Contractors Association (NECA): National Electrical Installation Standards.
 2. National Electrical Manufacturers Association (NEMA):
 - a. 250, Enclosures for Electrical Equipment (1000 Volts Maximum).
 - b. Z535.4, Product Safety Signs and Labels.
 3. National Fire Protection Association (NFPA): 70, National Electrical Code (NEC).

1.03 DESIGN REQUIREMENTS

- A. Provide anchorage and bracing design drawings, calculations, and related information where required under Section 01 88 15, Anchorage and Bracing.
- B. General:
1. Interpretation of Drawings:
 - a. Equipment sizes and locations shown on Drawings are estimated. Before installing any wire or conduit, the Electrical Contractor shall obtain the exact equipment requirements, including wire and conduit entrance location and install wire, conduit, disconnect switches, motor starters, overload heaters, circuit breakers or other items of the correct size and location, for the equipment actually installed. However, wire and conduit sizes shown on Drawings shall be taken as a minimum and shall not be reduced.
 - b. Intent:
 - 1) Drawings show the principal engineering design elements of the electrical installation.
 - 2) They are not intended as detailed (construction installation) drawings for electrical work but as a complement to the Specifications to clarify principal features of the electrical systems.

- 3) It is the intent of this section that all equipment and devices, furnished and installed under this and other sections of this Project, be properly connected and interconnected with other equipment so as to render the installations complete for successful operation, regardless of whether all the connections and interconnections are specifically mentioned in the Contract Documents.
- c. Contractor shall submit a complete conduit and wire schedule for all conduit and wiring prior to installing any as described in Article Submittals. Conduit and wire sizes are shown on the Drawings for the power conduits only. The Contractor shall verify all necessary conduit and wiring with the approved shop drawings of all equipment in this Contract prior to submitting a complete conduit and wire schedule.
2. The Contractor shall check with manufacturers as to physical sizes of equipment to ensure that it will fit in spaces assigned and shall instruct manufacturers as to maximum shipping sizes of equipment that can be accommodated in the moving of equipment from delivery vehicle through available accesses in any given building to the space in which it will be installed.
3. Excavation, and backfill for exterior conduit and underground duct bank installation shall conform to applicable requirements but shall be included as part of this Contract.
4. Electrical duct banks, lighting pole foundations, electrical equipment pads, and electrical handholes and manholes and castings shall be constructed. Special electrical equipment inserts and concrete for encasement of buried conduits are included. Concrete shall be installed in accordance with the applicable requirements of Section 03 30 10, Structural Concrete of these Specifications. Substation and motor control center foundation pads and anchor bolts required for installation of electrical equipment shall be furnished.
5. Connections to existing facilities are included as shown on the Contract Drawings and as required to complete the electrical work.
6. Cutting and patching including all sealants and caulking required are included as described in Section 02 41 00, Demolition, and Section 03 30 10, Structural Concrete.
7. Work shall include scope as specified in Section 02 41 00, Demolition.
8. Equipment that will require electrical Work is specified in Divisions 2 through 40.
9. Valves and appurtenances are specified in Section 40 27 02, Process Valves and Operators.
10. Temporary electricity is included as required.
11. The level of service and control existing at the start of the Contract shall be maintained at all times, except as required during the actual change over to the new equipment.

1.04 SUBMITTALS

A. Action Submittals:

1. Provide manufacturers' data for the following:
 - a. Electrical service components.
 - b. Nameplates, signs, and labels.
2. Anchorage and bracing drawings and catalog information, as required by Section 01 88 15, Anchorage and Bracing, for loads in Section 01 61 00, Common Product Requirements.
3. Conduit and wire layout drawings, showing the location, elevation and size of all conduits, boxes and other electrical equipment, and the number, size and use of conductors, and conduit numbers from schedule provided in the conduit and wire schedule. These drawings shall be updated during construction and will become record drawings at the conclusion of the Contract.
4. Complete conduit and wire schedule of all conduit and wiring on the Project. Conduit and wire sizes are shown for 480V power wiring on the Drawings. Duct bank conduit sizes are also shown on the Drawings. The Contractor shall size and provide all conduit and wire required for the complete Contract. Contractor shall verify all conduit and wiring shown on the Drawings with approved shop drawings prior to submitting schedule for review. Provide conduit number (provided by County), conduit size, wire quantity and size, "from" and "to" locations, and wire purpose and type. All conduit and wire types shall comply with Division 26, Electrical. Some conduit and wire sizes are shown on the Drawings and are a minimum size. Contractor shall provide a complete conduit and wire schedule of all necessary conduit and wiring to connect all equipment requiring conduit and wiring. Schedule shall comply with the specific conduit and wire requirements as specified in those sections.
5. There will be no payment made for Work or materials furnished as part of Division 26, Electrical until shop drawings for the particular Work are submitted and approved.

- B. Informational Submittals: Anchorage and bracing calculations, as required by Section 01 88 15, Anchorage and Bracing, for loads in Section 01 61 00, Common Product Requirements.

1.05 QUALITY ASSURANCE

- A. Provide the Work in accordance with NFPA 70. Where required by Authority Having Jurisdiction (AHJ), material and equipment shall be labeled or listed by a nationally recognized testing laboratory or other organization acceptable to the AHJ, in order to provide a basis for approval under the NEC.

- B. Materials and equipment manufactured within the scope of standards published by UL shall conform to those standards and shall have an applied UL listing mark or label.
- C. Provide materials and equipment acceptable to AHJ for Class, Division, and Group of hazardous area indicated.

1.06 ENVIRONMENTAL CONDITIONS

- A. The following areas are classified as indoor and dry:
 - 1. Control Rooms.
 - 2. Electrical Rooms.
- B. All other areas are classified nonhazardous, wet, and corrosive. Use materials and methods required for such areas as specified.

PART 2 PRODUCTS

2.01 GENERAL

- A. Where two or more units of the same class of material or equipment are required, provide products of a single manufacturer. Component parts of materials or equipment need not be products of the same manufacturer.
- B. Material and equipment installed in heated and ventilated areas shall be capable of continuous operation at their specified ratings within an ambient temperature range of 40 degrees F to 104 degrees F.
- C. Materials and equipment installed outdoors shall be capable of continuous operation at their specified rating within the ambient temperature range stated in Section 01 61 00, Common Product Requirements.
- D. Equip panels installed outdoors in direct sun with sun shields.

2.02 EQUIPMENT FINISH

- A. Manufacturer's standard finish color, except where specific color is indicated.

2.03 NAMEPLATES

- A. Material: Laminated plastic.
- B. Attachment Screws: Stainless Steel.
 - 1. Adhesive: Single-part, room temperature vulcanizing adhesive suitable for the environment and materials installed. Use adhesive on NEMA 4 or NEMA 4X enclosures only.

- C. Color: White, engraved to a black core.
- D. Letter Height:
 - 1. Pushbuttons/Selector Switches: 1/8 inch.
 - 2. Other Electrical Equipment: 1/4 inch.

2.04 SIGNS AND LABELS

- A. Sign size, lettering, and color shall be in accordance with NEMA Z535.4.

PART 3 EXECUTION

3.01 GENERAL

- A. Electrical Drawings show general locations of equipment, devices, and raceway, unless specifically dimensioned. Contractor shall be responsible for actual location of equipment and devices and for proper routing and support of raceways, subject to approval of Engineer.
- B. Check approximate locations of light fixtures, switches, electrical outlets, equipment, and other electrical system components shown on Drawings for conflicts with openings, structural members, and components of other systems and equipment having fixed locations. In the event of conflicts, notify Engineer in writing.
- C. Install work in accordance with NECA Standard of Installation, unless otherwise specified.
- D. Keep openings in boxes and equipment closed during construction.
- E. Lay out work carefully in advance. Do not cut or notch any structural member or building surface without specific approval of Engineer. Carefully perform cutting, channeling, chasing, or drilling of floors, walls, partitions, ceilings, paving, or other surfaces required for the installation, support, or anchorage of conduit, raceways, or other electrical materials and equipment. Following such work, restore surfaces to original condition.

3.02 ANCHORING, BRACING, AND MOUNTING

- A. Equipment anchoring and mounting shall be in accordance with manufacturer's requirements for Project design criteria provided in Section 01 61 00, Common Product Requirements, to meet the requirements of Section 01 88 15, Anchorage and Bracing.

3.03 COMBINING CIRCUITS INTO COMMON RACEWAY

- A. Drawings show each homerun circuit to be provided. Do not combine power or control circuits into common raceways.

- B. Homerun circuits shown on Drawings indicate functional wiring requirements for power and control circuits. Conduit wire sizes are shown on Drawings. Any proposed changes shall be approved by the Engineer prior to making any changes.

3.04 NAMEPLATES, SIGNS, AND LABELS

- A. Arc Flash Protection Warning Signs: None are required in this project.
- B. Available Fault Current Signs: None are required in this project.
- C. Multiple Power Supply Sign: Install permanent plaque or directory at each service disconnect location denoting other services, feeders, and branch circuits supplying the building, and the area served by each.
- D. Equipment Nameplates:
 - 1. Provide a nameplate to label electrical equipment including switchgear, switchboards, motor control centers, panelboards, motor starters, transformers, terminal junction boxes, disconnect switches, switches and control stations.
 - 2. Switchgear, motor control center, transformer, and terminal junction box nameplates shall include equipment designation.
 - 3. Disconnect switch, starter, and control station nameplates shall include name and number of equipment powered or controlled by that device.
 - 4. Switchboard and panelboard nameplates shall include equipment designation, service voltage, and phases.

3.05 LOAD BALANCE

- A. Drawings and Specifications indicate circuiting to electrical loads and distribution equipment.
- B. Balance electrical load between phases as nearly as possible on switchboards, panelboards, motor control centers, and other equipment where balancing is required.
- C. When loads must be reconnected to different circuits to balance phase loads, maintain accurate record of changes made, and provide circuit directory that lists final circuit arrangement.

3.06 CLEANING AND TOUCHUP PAINTING

- A. Cleaning: Throughout the Work, clean interior and exterior of devices and equipment by removing debris and vacuuming.

B. Touchup Paint:

1. Touchup scratches, scrapes and chips on exterior and interior surfaces of devices and equipment with finish matching type, color, and consistency and type of surface of original finish.
2. If extensive damage is done to equipment paint surfaces, refinish entire equipment in a manner that provides a finish equal to or better than factory finish, that meets requirements of Specification, and is acceptable to Engineer.

3.07 PROTECTION FOLLOWING INSTALLATION

- A. Protect materials and equipment from corrosion, physical damage, and effects of moisture on insulation and contact surfaces.
- B. When equipment intended for indoor installation is installed at Contractor's convenience in areas where subject to dampness, moisture, dirt or other adverse atmosphere until completion of construction, ensure adequate protection from these atmospheres is provided and acceptable to Engineer.

END OF SECTION

SECTION 26 05 04
BASIC ELECTRICAL MATERIALS AND METHODS

PART 1 GENERAL

1.01 REFERENCES

- A. The following is a list of standards which may be referenced in this section:
1. ASTM International (ASTM):
 - a. A1011/A1011M, Standard Specification for Steel, Sheet, and Strip, Hot-Rolled, Carbon, Structural, High-Strength Low Alloy and High-Strength Low Alloy Formability.
 - b. E814, Method of Fire Tests of Through-Penetration Fire Stops.
 2. Canadian Standards Association (CSA).
 3. Institute of Electrical and Electronics Engineers, Inc. (IEEE): 18, Standard for Shunt Power Capacitors.
 4. International Society of Automation (ISA): RP12.06.01, Wiring Practices for Hazardous (Classified) Locations Instrumentation–Part 1: Intrinsic Safety.
 5. National Electrical Manufacturers Association (NEMA):
 - a. 250, Enclosures for Electrical Equipment (1,000 Volts Maximum).
 - b. C12.1, Code for Electricity Metering.
 - c. C12.6, Phase-Shifting Devices Used in Metering, Marking and Arrangement of Terminals.
 - d. ICS 2, Industrial Control and Systems: Controllers, Contactors, and Overload Relays Rated 600 Volts.
 - e. ICS 5, Industrial Control and Systems: Control Circuit and Pilot Devices.
 - f. KS 1, Enclosed and Miscellaneous Distribution Switches (600 Volts Maximum).
 6. National Fire Protection Association (NFPA): 70, National Electrical Code (NEC).
 7. Underwriters Laboratories, Inc. (UL):
 - a. 98, Standard for Enclosed and Dead-Front Switches.
 - b. 248, Standard for Low Voltage Fuses.
 - c. 486E, Standard for Equipment Wiring Terminals for use with Aluminum and/or Copper Conductors.
 - d. 489, Standard for Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit Breaker Enclosures.
 - e. 508, Standard for Industrial Control Equipment.
 - f. 810, Standard for Capacitors.
 - g. 943, Standard for Ground-Fault Circuit-Interrupters.
 - h. 1059, Standard for Terminal Blocks.
 - i. 1479, Fire Tests of Through-Penetration Fire Stops.

1.02 SUBMITTALS

A. Action Submittals:

1. Provide manufacturers' data for the following:
 - a. Control devices.
 - b. Control relays.
 - c. Circuit breakers.
 - d. Fused switches.
 - e. Nonfused switches.
 - f. Timers.
 - g. Fuses.
 - h. Magnetic contactors.
 - i. Intrinsic safety barriers.
 - j. Firestopping.
 - k. Enclosures: Include enclosure data for products having enclosures.
2. Seismic anchorage and bracing drawings and cut sheets, as required by Section 01 88 15, Anchorage and Bracing.

B. Informational Submittals: Seismic anchorage and bracing calculations as required by Section 01 88 15, Anchorage and Bracing.

PART 2 PRODUCTS

2.01 MOLDED CASE CIRCUIT BREAKER THERMAL MAGNETIC, LOW VOLTAGE

A. General:

1. Type: Molded case.
2. Trip Ratings: 15 amps to 800 amps.
3. Voltage Ratings: 120, 240, 277, 480, and 600V ac.
4. Suitable for mounting and operating in any position.
5. UL 489.

B. Operating Mechanism:

1. Overcenter, trip-free, toggle type handle.
2. Quick-make, quick-break action.
3. Locking provisions for padlocking breaker in OPEN position.
4. ON/OFF and TRIPPED indicating positions of operating handle.
5. Operating handle to assume a CENTER position when tripped.

- C. Trip Mechanism:
1. Individual permanent thermal and magnetic trip elements in each pole.
 2. Variable magnetic trip elements with a single continuous adjustment 3X to 10X for frames greater than 100 amps.
 3. Two and three pole, common trip.
 4. Automatically opens all poles when overcurrent occurs on one pole.
 5. Test button on cover.
 6. Calibrated for 40 degrees C ambient, unless shown otherwise.
 7. Do not provide single-pole circuit breakers with handle ties where multi-pole circuit breakers are shown.
- D. Short Circuit Interrupting Ratings: Equal to, or greater than, available fault current or interrupting rating shown.
- E. Ground Fault Circuit Interrupter (GFCI): Where indicated, equip breaker as specified above with ground fault sensor and rated to trip on 5-mA ground fault within 0.025 second (UL 943, Class A sensitivity, for protection of personnel).
1. Ground fault sensor shall be rated same as circuit breaker.
 2. Push-to-test button.
- F. Equipment Ground Fault Interrupter (EGFI): Where indicated, equip breaker specified above with ground fault sensor and rated to trip on 30-mA ground fault (UL-listed for equipment ground fault protection).
- G. Magnetic Only Type Breakers: Where shown; instantaneous trip adjustment which simultaneously sets magnetic trip level of each individual pole continuously through a 3X to 10X trip range.
- H. Accessories: Shunt trip, auxiliary switches, handle lock ON devices, mechanical interlocks, key interlocks, unit mounting bases, double lugs as shown or otherwise required. Shunt trip operators shall be continuous duty rated or have coil-clearing contacts.
- I. Connections:
1. Supply (line side) at either end.
 2. Mechanical wire lugs, except crimp compression lugs where shown.
 3. Lugs removable/replaceable for breaker frames greater than 100 amperes.
 4. Suitable for 75 degrees C rated conductors without derating breaker or conductor ampacity.

- J. Enclosures for Independent Mounting:
 - 1. See Article Enclosures.
 - 2. Service Entrance Use: Breakers in required enclosure and required accessories shall be UL 489 listed.
 - 3. Interlock: Enclosure and switch shall interlock to prevent opening cover with switch in the ON position. Provide bypass feature for use by qualified personnel.

2.02 FUSED SWITCH, INDIVIDUAL, LOW VOLTAGE

- A. UL 98 listed for use and location of installation.
- B. NEMA KS 1.
- C. Short Circuit Rating: 200,000 amps rms symmetrical with Class R, Class J, or Class L fuses installed.
- D. Quick-make, quick-break, motor rated, load-break, heavy-duty (HD) type with external markings clearly indicating ON/OFF positions.
- E. Connections:
 - 1. Mechanical lugs, except crimp compression lugs where shown.
 - 2. Lugs removable/replaceable.
 - 3. Suitable for 75 degrees C rated conductors at NEC 75 degrees C ampacity.
- F. Fuse Provisions:
 - 1. 30-amp to 600-amp rated shall incorporate rejection feature to reject all fuses except Class R.
 - 2. 601-amp rated and greater shall accept Class L fuses, unless otherwise shown.
- G. Enclosures: See Article Enclosures.
- H. Interlock: Enclosure and switch to prevent opening cover with switch in ON position. Provide bypass feature for use by qualified personnel.

2.03 NONFUSED SWITCH, INDIVIDUAL, LOW VOLTAGE

- A. NEMA KS 1.
- B. Quick-make, quick-break, motor rated, load-break, heavy-duty (HD) type with external markings clearly indicating ON/OFF positions.
- C. Lugs: Suitable for use with 75 degrees C wire at NEC 75 degrees C ampacity.

- D. Auxiliary Contact:
 - 1. Operation: Make before power contacts make and break before power contacts break.
 - 2. Contact Rating: 7,200VA make, 720VA break, at 600V, NEMA ICS 5 Designation A600.
- E. Enclosures: See Article Enclosures.
- F. Interlock: Enclosure and switch to prevent opening cover with switch in ON position. Provide bypass feature for use by qualified personnel.

2.04 FUSE, 250-VOLT AND 600-VOLT

- A. Power Distribution, General:
 - 1. Current-limiting, with 200,000 ampere rms interrupting rating.
 - 2. Provide to fit mountings specified with switches.
 - 3. UL 248.
- B. Power Distribution, Ampere Ratings 1 Amp to 600 Amps:
 - 1. Class: RK-1.
 - 2. Type: Dual element, with time delay.
 - 3. Manufacturers and Products:
 - a. Bussmann; Types LPS-RK (600 volts) and LPN-RK (250 volts).
 - b. Littelfuse; Types LLS-RK (600 volts) and LLN-RK (250 volts).
- C. Power Distribution, Ampere Ratings 601 Amps to 6,000 Amps:
 - 1. Class: L.
 - 2. Double O-rings and silver links.
 - 3. Manufacturers and Products:
 - a. Bussmann; Type KRP-C.
 - b. Littelfuse, Inc.; Type KLPC.
- D. Cable Limiters:
 - 1. 600V or less; crimp to copper cable, bolt to bus or terminal pad.
 - 2. Manufacturer and Product: Bussmann; K Series.
- E. Ferrule:
 - 1. 600V or less, rated for applied voltage, small dimension.
 - 2. Ampere Ratings: 1/10 amp to 30 amps.
 - 3. Dual-element time-delay, time-delay, or nontime-delay as required.
 - 4. Provide with blocks or holders as indicated and suitable for location and use.

5. Manufacturers:
 - a. Bussmann.
 - b. Littlefuse, Inc.

2.05 PUSHBUTTON, INDICATING LIGHT, AND SELECTOR SWITCH

- A. Contact Rating: 7,200VA make, 720VA break, at 600V, NEMA ICS 5 Designation A600.
- B. Selector Switch Operating Lever: Standard, 30 mm.
- C. Indicating Light: LED, full voltage, 30 mm.
- D. Pushbutton Color:
 1. ON or START: Black, 30 mm.
 2. OFF or STOP: Red, 30 mm.
- E. Pushbutton and selector switch lockable in OFF position where indicated.
- F. Legend Plate:
 1. Material: Aluminum.
 2. Engraving: Enamel filled in high contrasting color.
 3. Text Arrangement: 11-character/spaces on one line, 14-character/spaces on each of two lines, as required, indicating specific function.
 4. Letter Height: 7/64 inch.
- G. Manufacturers and Products:
 1. Heavy-Duty, Watertight, and Corrosion-Resistant Type:
 - a. Square D Co.; Type SK.
 - b. Eaton/Cutler-Hammer; Type E34.
 - c. Rockwell/Allen-Bradley; 800H.

2.06 TERMINAL BLOCK, 600 VOLTS

- A. UL 486E and UL 1059.
- B. Size components to allow insertion of necessary wire sizes.
- C. Capable of termination of control circuits entering or leaving equipment, panels, or boxes.
- D. Screw clamp compression, dead front barrier type, with current bar providing direct contact with wire between compression screw and yoke.
- E. Yoke, current bar, and clamping screw of high strength and high conductivity metal.

- F. Yoke shall guide all strands of wire into terminal.
- G. Current bar shall ensure vibration-proof connection.
- H. Terminals:
 - 1. Capable of wire connections without special preparation other than stripping.
 - 2. Capable of jumper installation with no loss of terminal or rail space.
 - 3. Individual, rail mounted.
- I. Marking system, allowing use of preprinted or field-marked tags.
- J. Manufacturers:
 - 1. Rockwell/Allen-Bradley.
 - 2. Phoenix Contact.

2.07 MAGNETIC CONTROL RELAY

- A. Industrial control with field convertible contacts rated 10 amps continuous, 7,200VA make, 720VA break.
- B. NEMA ICS 2, Designation: A600 (600 volts).
- C. Time Delay Relay Attachment:
 - 1. Pneumatic type, timer adjustable as shown.
 - 2. Field convertible from ON delay to OFF delay and vice versa.
- D. Latching Attachment: Mechanical latch, having unlatching coil and coil clearing contacts.
- E. Manufacturers and Products:
 - 1. Eaton/Cutler-Hammer; D26 Type M.
 - 2. Rockwell/Allen-Bradley.
 - 3. Square D; Type X.

2.08 TIME DELAY RELAY

- A. Industrial relay with contacts rated 5 amps continuous, 3,600VA make, 360VA break.
- B. NEMA ICS 2 Designation: B150 (150 volts).
- C. Solid-state electronic, field convertible ON/OFF delay.

- D. One normally open and one normally closed contact (minimum).
- E. Repeat accuracy plus or minus 2 percent.
- F. Timer adjustment from 1 second to 60 seconds, unless otherwise indicated on Drawings.
- G. Manufacturers and Products:
 - 1. Square D Co.; Type XO.
 - 2. Eaton/Cutler-Hammer; Type D26MR.
 - 3. Rockwell/Allen-Bradley.

2.09 RESET TIMER

- A. Drive: Synchronous motor, solenoid-operated clutch.
- B. Mounting: Semiflush panel.
- C. Contacts: 10 amps, 120 volts.
- D. Manufacturers and Products:
 - 1. Eagle Signal Controls; Bulletin 125.
 - 2. Automatic Timing and Controls; Bulletin 305.

2.10 ELAPSED TIME METER

- A. Drive: Synchronous motor.
- B. Range: 0 hour to 99,999.9 hours, nonreset type.
- C. Mounting: Semiflush panel.
- D. Manufacturers and Products:
 - 1. General Electric Co.; Type 240, 2-1/2-inch Big Look.
 - 2. Eagle Signal Controls; Bulletin 705.

2.11 MAGNETIC CONTACTOR

- A. UL listed.
- B. Electrically operated, electrically held.
- C. Main Contacts:
 - 1. Power driven in one direction with mechanical spring dropout.

2. Silver alloy with wiping action and arc quenchers.
 3. Continuous-duty, rated 20 amperes.
 4. Poles: Two.
- D. Control: Two-wire.
- E. Auxiliary Contacts: Quantity as shown, rated 7200VA make, 720VA break, at 600V, A600 per NEMA ICS 5.
- F. Enclosures: See Article Enclosures.
- G. Manufacturers and Products:
1. Eaton/Cutler-Hammer; Class A201.
 2. Rockwell/Allen-Bradley.
 3. Square D Co.; Class 8910.

2.12 PHASE MONITOR RELAY

- A. Features:
1. Voltage and phase monitor relay shall drop out on low voltage, voltage unbalance, loss of phase, or phase reversal.
 2. Contacts: Single-pole, double-throw, 10 amperes, 120/240V ac. Where additional contacts are shown or required, provide magnetic control relays.
 3. Adjustable trip and time delay settings.
 4. Transient Protection: 1,000V ac.
 5. Mounting: Multipin plug-in socket base.
- B. Manufacturer and Product: Automatic Timing and Controls; SLD Series.

2.13 MAGNETIC LIGHTING CONTACTOR

- A. Comply with NEMA ICS 2; provide UL 508 listing.
- B. Electrically operated by dual-acting, single coil mechanism.
- C. Inherently interlocked and electrically held in CLOSED position.
- D. Main Contacts:
1. Double-break, continuous-duty, rated 30 amperes, 600 volts, withstand rating of 22,000 amps rms symmetrical at 250 volts.
 2. Marked for electric discharge lamps, tungsten, and general purpose loads.
 3. Position not dependent on gravity, hooks, latches, or semipermanent magnets.

4. Capable of operating in any position.
 5. Visual indication for each contact.
- E. Auxiliary contact relay for two-wire control.
- F. Fully rated neutral terminal.
- G. Provision for remote pilot lamp with use of auxiliary contacts.
- H. Clamp type, self-rising terminal plates for solderless connections.
- I. Enclosures: See Article Enclosures.
- J. Manufacturers and Products:
1. ASCO.
 2. Eaton/Cutler-Hammer; Class A202.
 3. Rockwell/Allen-Bradley.
 4. Square D; Class 8903, Type L (electrically held).

2.14 INDUSTRIAL CAPACITORS

- A. UL 810, IEEE 18, and NFPA 70, Article 460.
- B. Three-phase capacitor units containing internally mounted, indicating type, high interrupting-capacity, current-limiting fuses, and discharge resistors.
- C. Enclosure: See Article Enclosures.
- D. Units containing PCB dielectric fluid are unacceptable.
- E. Kilovar Ratings:
1. Check motor nameplate and manufacturer's power factor and no-load current data for actual motor installed.
 2. Reduce capacitor rating, if required, to not exceed motor manufacturer's recommended maximum size, and to not exceed value required to raise motor no-load power factor to 0.95.
- F. Manufacturers:
1. General Electric Co.
 2. Square D Co.

2.15 SINGLE PHASE EQUIPMENT CONTROLLERS AND DISCONNECT SWITCHES

- A. All single phase motors rated less than 10 Amps and ALL single phase equipment rated less than 10 Amps shall be furnished with single phase equipment controllers and/or single phase disconnects as part of this section.

This includes any motorized equipment furnished under this Contract and all single phase valve actuators, instruments, flowmeters, controls, pumps, blowers, heaters and all other similar equipment receiving single phase power.

B. Single Phase Equipment Controllers: Furnish and install at all 120 volt motors and equipment and remotely where shown or specified.

1. Type: Toggle operated, non-reversing 2-pole, horsepower rated with thermal overload protection with interchangeable heaters and rated for the equipment controlled in accordance with the National Electrical Code.
2. HAND-OFF-AUTO selector switch where shown on Drawings.
3. Enclosure: NEMA 4 with gaskets for all non-hazardous locations. NEMA 7 for all hazardous locations. Provide terminal blocks for landing field wiring and fusing sized for load.
4. Padlockable in ON and OFF positions.
5. Provide a laminated engraved nameplate for each disconnect. Comply with Section 26 05 02, Basic Electrical Requirements.
6. Products and Manufacturers:
 - a. Allen-Bradley.
 - b. Cross-Hinds.
 - c. Square D Company.
 - d. Or approved equal.

C. Single Phase Equipment Disconnect Switches:

1. For all non-motor, 120 volt equipment, furnish and install a local disconnect switch. Disconnect switches shall be similar to the controllers described above except without thermal overload protection.
2. Provide a laminated engraved nameplate for each disconnect. Comply with 26 05 02, Basic Electrical Requirements.

2.16 SUPPORT AND FRAMING CHANNELS

- A. PVC-Coated Framing Channel: Carbon steel framing channel with 40-mil polyvinyl chloride coating.
- B. Stainless Steel Framing Channel: Rolled, Type 316 stainless steel, 12-gauge minimum.
- C. Extruded Aluminum Framing Channel:
 1. Material: Extruded from Type 6063-T6 aluminum alloy.
 2. Fittings fabricated from Alloy 5052-H32.

- D. Manufacturers:
 - 1. B-Line Systems, Inc.
 - 2. Unistrut Corp.
 - 3. Aickinstrut.

2.17 INTRINSIC SAFETY BARRIER

- A. Provides a safe energy level for exposed wiring in a Class I, Division 1 or Division 2 hazardous area when circuit is connected to power source in nonhazardous area.
- B. Rating: Power source shall be rated 24 volts dc, nominal, with not more than 250 volts available under fault conditions.
- C. Contact Rating: 5 amps, 250 volts ac.
- D. Mounting: Rail or surface.
- E. Manufacturers and Products:
 - 1. MTL, Inc.; Series 2000 or Series 3000.
 - 2. R. Stahl, Inc.

2.18 FIRESTOPS

- A. General:
 - 1. Provide UL 1479 classified hourly fire rating equal to, or greater than, the assembly penetrated.
 - 2. Prevent the passage of cold smoke, toxic fumes, and water before and after exposure to flame.
 - 3. Sealants and accessories shall have fire-resistance ratings as established by testing identical assemblies in accordance with ASTM E814, by Underwriters Laboratories, Inc., or other testing and inspection agency acceptable to authorities having jurisdiction.
- B. Firestop System:
 - 1. Formulated for use in through-penetration firestopping around cables, conduit, pipes, and duct penetrations through fire-rated walls and floors.
 - 2. Fill, Void, or Cavity Material: 3M Brand Fire Barrier Caulk CP25, Putty 303, Wrap/Strip FS195, Composite Sheet CS195 and Penetration Sealing Systems 7902 and 7904 Series.
 - 3. Two-Part, Foamed-In-Place, Silicone Sealant: Dow Corning Corp. Fire Stop Foam, General Electric Co. Pensil 851.

4. Fire Stop Devices: See Section 26 05 33, Raceway and Boxes, for raceway and cable fittings.

2.19 ENCLOSURES

- A. Finish: Sheet metal structural and enclosure parts shall be completely painted using an electrodeposition process so interior and exterior surfaces as well as bolted structural joints have a complete finish coat on and between them.
- B. Color: Manufacturer's standard color (gray) baked-on enamel, unless otherwise shown.
- C. Barriers: Provide metal barriers within enclosures to separate wiring of different systems and voltage.
- D. Enclosure Selections:
 1. Except as shown otherwise, provide electrical enclosures according to the following table:

| Enclosures | | | |
|--------------------|--|--------------------|---------------------------|
| Location | Finish | Environment | NEMA 250 Type |
| Indoor | Finished Electrical and Control Rooms (Only) | Dry | 12 |
| Indoor and Outdoor | Any | Wet and Corrosive | 4X 316 Stainless Steel |
| Indoor and Outdoor | Any | Hazardous Gas | 7 |
| Indoor and Outdoor | Any | Hazardous Dust | 9 |

PART 3 EXECUTION

3.01 GENERAL

- A. Install equipment in accordance with manufacturer's recommendations.

3.02 PUSHBUTTON, INDICATING LIGHT, AND SELECTOR SWITCH

- A. Install heavy-duty, oil-tight type in nonhazardous, indoor, dry locations, including motor control centers, control panels, and individual stations, unless otherwise shown.
- B. Install heavy-duty, watertight and corrosion-resistant type in nonhazardous, outdoor, or normally wet areas, unless otherwise shown.

3.03 INDUSTRIAL CAPACITORS

- A. Provide suitable hangers or mounting brackets for wall or ceiling mounting.

3.04 SUPPORT AND FRAMING CHANNEL

- A. Install where required for mounting and supporting electrical equipment, raceway, and cable tray systems.

- B. Channel Type:

1. Interior, Wet or Dry (Noncorrosive) Locations:
 - a. Aluminum Raceway: Stainless steel with neoprene material isolators.
 - b. PVC-Coated Conduit: PVC coated.
2. Interior, Corrosive (Wet or Dry) Locations:
 - a. Aluminum Raceway: Extruded aluminum.
 - b. PVC Conduit: Type 316 stainless steel or nonmetallic.
 - c. PVC-Coated Steel Conduit and Other Systems Not Covered: PVC-coated steel.
3. Outdoor Wet and Corrosive Locations:
 - a. PVC Conduit: Type 316 stainless steel or nonmetallic.
 - b. Aluminum Raceway: Aluminum or carbon steel with neoprene material isolators.
 - c. PVC-Coated Steel Conduit and Other Systems Not Covered: PVC-coated steel.
4. Aluminum Railings: Devices mounted on aluminum railing shall use aluminum framing channel.

- C. Paint cut ends prior to installation with the following:

1. Carbon Steel Channel: Zinc-rich primer.
2. Painted Channel: Rust-inhibiting epoxy or acrylic paint.
3. Nonmetallic Channel: Epoxy resin sealer.
4. PVC-Coated Channel: PVC patch.

3.05 INTRINSIC SAFETY BARRIERS

- A. Install in compliance with ISA RP12.06.01.
- B. Arrange conductors such that wiring from hazardous areas cannot short to wiring from nonhazardous area.
- C. Stencil "INTRINSICALLY SAFE CIRCUIT" on all boxes enclosing barriers.

3.06 FIRESTOPS

- A. Install in strict conformance with manufacturer's instructions. Comply with installation requirements established by testing and inspecting agency.
- B. Sealant: Install sealant including forming, packing, and other accessory materials, to fill openings around electrical services penetrating floors and walls, to provide firestops with fire-resistance ratings indicated for floor or wall assembly in which penetration occurs.

END OF SECTION

SECTION 26 05 05 CONDUCTORS

PART 1 GENERAL

1.01 REFERENCES

- A. The following is a list of standards which may be referenced in this section:
1. Association of Edison Illuminating Companies (AEIC): CS 8, Specification for Extruded Dielectric Shielded Power Cables Rated 5 kV through 46 kV.
 2. ASTM International (ASTM):
 - a. A167, Standard Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip.
 - b. B3, Standard Specification for Soft or Annealed Copper Wire.
 - c. B8, Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft.
 - d. B496, Standard Specification for Compact Round Concentric-Lay-Stranded Copper Conductors.
 3. Institute of Electrical and Electronics Engineers, Inc. (IEEE):
 - a. 48, Standard Test Procedures and Requirements for Alternating-Current Cable Terminations Used on Shielded Cables Having Laminated Insulation Rated 2.5 kV through 765 kV or Extruded Insulation Rated 2.5 kV Through 500 kV.
 - b. 386, Standard for Separable Insulated Connector Systems for Power Distribution Systems Above 600V.
 - c. 404, Standard for Extruded and Laminated Dielectric Shielded Cable Joints Rated 2500 V to 500000 V.
 4. Insulated Cable Engineer's Association, Inc. (ICEA):
 - a. S-58-679, Standard for Control Cable Conductor Identification.
 - b. S-73-532, Standard for Control Thermocouple Extensions and Instrumentation Cables.
 - c. T-29-520, Conducting Vertical Cable Tray Flame Tests with Theoretical Heat Input of 210,000 Btu/hour.
 5. National Electrical Manufacturers' Association (NEMA):
 - a. CC 1, Electric Power Connectors for Substations.
 - b. WC 57, Standard for Control, Thermocouple Extension, and Instrumentation Cables.
 - c. WC 70, Standard for Power Cables Rated 2000 Volts or Less for the Distribution of Electrical Energy.
 - d. WC 71, Standard for Nonshielded Cables Rated 2001-5000 Volts for Use in the Distribution of Electric Energy.
 - e. WC 74, 5-46 kV Shielded Power Cable for Use in the Transmission and Distribution of Electric Energy.

6. National Fire Protection Association (NFPA):
 - a. 70, National Electrical Code (NEC).
 - b. 262, Standard Method of Test for Flame Travel and Smoke of Wires and Cables for Use in Air-Handling Spaces.
7. Telecommunications Industry Association (TIA): TIA-568-C, Commercial Building Telecommunications Cabling Standard.
8. Underwriters Laboratories Inc. (UL):
 - a. 13, Standard for Safety for Power-Limited Circuit Cables.
 - b. 44, Standard for Safety for Thermoset-Insulated Wires and Cables.
 - c. 62, Standard for Safety for Flexible Cord and Cables.
 - d. 486A-486B, Standard for Safety for Wire Connectors.
 - e. 486C, Standard for Safety for Splicing Wire Connectors.
 - f. 510, Standard for Safety for Polyvinyl Chloride, Polyethylene, and Rubber Insulating Tape.
 - g. 854, Standard for Safety for Service-Entrance Cables.
 - h. 1072, Standard for Safety for Medium-Voltage Power Cables.
 - i. 1277, Standard for Safety for Electrical Power and Control Tray Cables with Optional Optical-Fiber Members.
 - j. 1569, Standard for Safety for Metal-Clad Cables.
 - k. 1581, Standard for Safety for Reference Standard for Electrical Wires, Cables, and Flexible Cords.

1.02 SUBMITTALS

A. Action Submittals:

1. Product Data:
 - a. Wire and cable.
 - b. Wire and cable accessories.
2. Manufactured Wire Systems:
 - a. Product data.
 - b. Rating information.
 - c. Dimensional drawings.
 - d. Special fittings.
3. Busway:
 - a. Product data.
 - b. Rating information.
 - c. Dimensional drawings.
 - d. Special fitting.
 - e. Equipment interface information for equipment to be connected to busways.

4. Cable Pulling Calculations:
 - a. Ensure submitted and reviewed before cable installation.
 - b. Provide for the following cable installations:
 - 1) Medium voltage cable runs that cannot be hand pulled.
 - 2) Multiconductor 600-volt cable sizes larger than 2 AWG that cannot be hand pulled.
 - 3) Power and control conductor, and control and instrumentation cable installations in ductbanks.
 - 4) Feeder circuits; single conductors #4/0 and larger.

B. Informational Submittals:

1. Journeyman lineman or electrician splicing credentials.
2. Certified Factory Test Report for conductors 600 volts and below.
3. Certified Factory Test Report per AEIC CS 8, including AEIC qualification report for conductors above 600 volts.

1.03 QUALITY ASSURANCE

A. Authority Having Jurisdiction (AHJ):

1. Provide the Work in accordance with NFPA 70. Where required by the AHJ, material and equipment shall be labeled or listed by a nationally recognized testing laboratory or other organization acceptable to the AHJ in order to provide a basis for approval under NEC.
2. Materials and equipment manufactured within the scope of standards published by Underwriters Laboratories Inc. shall conform to those standards and shall have an applied UL listing mark.

B. Terminations and Splices for Conductors above 600 Volts: Work shall be done by journeyman lineman with splicing credentials or electrician certified to use materials approved for cable splices and terminations.

PART 2 PRODUCTS

2.01 CONDUCTORS 600 VOLTS AND BELOW

A. Conform to applicable requirements of NEMA WC 70.

B. Conductor Type:

1. 120-Volt and 277-Volt Lighting, 10 AWG and Smaller: Solid copper.
2. 120-Volt Receptacle Circuits, 10 AWG and Smaller: Solid copper.
3. All Other Circuits: Stranded copper.

C. Insulation: Type THHN/THWN-2, except for sizes No. 6 and larger, with XHHW-2 insulation.

D. Flexible Cords and Cables:

1. Type SOW-A/50 with ethylene propylene rubber insulation in accordance with UL 62.
2. Conform to physical and minimum thickness requirements of NEMA WC 70.

2.02 CONDUCTORS ABOVE 600 VOLTS

A. EPR Insulated Cable:

1. Extrusion: Single-pass, triple-tandem, of conductor screen, insulation, and insulation screen.
2. Type: 5 kV, shielded, UL 1072, Type MV-105.
3. Conductors: Copper, concentric lay Class B round stranded in accordance with ASTM B3, ASTM B8, and ASTM B496.
4. Strand Fill: Waterproof strand compound enclosing conductors.
5. Conductor Screen: Extruded, semiconducting ethylene-propylene rubber in accordance with NEMA WC 71 and AEIC CS 8.
6. Insulation: 133 percent insulation level, ethylene-propylene rubber (EPR) containing no polyethylene, in accordance with NEMA WC 71, and AEIC CS 8.
7. Insulation Thickness: 115-mil, 5 kV, nominal.
8. Insulation Screen: Thermosetting, semiconducting ethylene-propylene rubber (EPR), extruded directly over insulation in accordance with NEMA WC 74 and AEIC CS 8.
9. Metallic Shield: Uncoated, 5-mil, copper shielding tape, helically applied with 12-1/2 percent minimum overlap.
10. Jacket: Extruded hypalon (chlorosulfonated polyethylene) chlorinated polyethylene (CPE) compound applied in accordance with NEMA WC 71 or NEMA WC 74.
11. Operating Temperature: 105 degrees C continuous normal operations, 130 degrees C emergency operating conditions, and 250 degrees C short-circuit conditions.
12. Manufacturers:
 - a. Okonite Co.
 - b. General Cable.
 - c. Southwire Co.

2.03 600-VOLT RATED CABLE

A. General:

1. Type TC, meeting requirements of UL 1277, including Vertical Tray Flame Test at 70,000 Btu per hour, and NFPA 70, Article 340, or UL 13 meeting requirements of NFPA 70, Article 725.

2. Permanently and legibly marked with manufacturer's name, maximum working voltage for which cable was tested, type of cable, and UL listing mark.
 3. Suitable for installation in open air, in cable trays, or conduit.
 4. Minimum Temperature Rating: 90 degrees C dry locations, 75 degrees C wet locations.
 5. Overall Outer Jacket: PVC, flame-retardant, sunlight- and oil-resistant.
- B. Type 3, 16 AWG, Twisted, Shielded Pair, 600V 90 degrees C.
Instrumentation Cable: Single pair, designed for noise rejection for process control, computer, or data log applications meeting NEMA WC 57 requirements.
1. Outer Jacket: 45-mil nominal thickness.
 2. Individual Pair Shield: 1.35-mil, double-faced aluminum/synthetic polymer overlapped to provide 100 percent coverage.
 3. Dimension: 0.31-inch nominal OD.
 4. Conductors:
 - a. Bare soft annealed copper, Class B, seven-strand concentric, meeting requirements of ASTM B8.
 - b. 20 AWG, seven-strand tinned copper drain wire.
 - c. Insulation: 15-mil nominal PVC.
 - d. Jacket: 4-mil nominal nylon.
 - e. Color Code: Pair conductors, black and red.
 5. Manufacturers:
 - a. Okonite Co.
 - b. Alpha Wire Corp.
 - c. Belden.
- C. Type 4, 16 AWG, Twisted, Shielded Triad 600V 90 degrees C
Instrumentation Cable: Single triad, designed for noise rejection for process control, computer, or data log applications meeting NEMA WC 57 requirements.
1. Outer Jacket: 45-mil nominal.
 2. Individual Pair Shield: 1.35-mil, double-faced aluminum/synthetic polymer, overlapped to provide 100 percent coverage.
 3. Dimension: 0.32-inch nominal OD.
 4. Conductors:
 - a. Bare soft annealed copper, Class B, seven-strand concentric, meeting requirements of ASTM B8.
 - b. 20 AWG, seven-strand, tinned copper drain wire.
 - c. Insulation: 15-mil nominal PVC.
 - d. Jacket: 4-mil nylon.
 - e. Color Code: Triad conductors black, red, and blue.

5. Manufacturers:
 - a. Okonite Co.
 - b. Alpha Wire Corp.
 - c. Belden.

2.04 SPECIAL CABLES

- A. Type 30, Unshielded Twisted Pair (UTP) Telephone and Data Cable, 300V:
 1. Category 6 UTP, UL listed, and third party verified to comply with TIA/EIA 568-C Category 6 requirements.
 2. Suitable for high speed network applications including gigabit ethernet and video. Cable shall be interoperable with other standards compliant products and shall be backward compatible with Category 5 and Category 5e.
 3. Provide four each individually twisted pair, 23 AWG conductors, with FEP insulation and blue PVC jacket.
 4. NFPA 70 Plenum (CMP) rated; comply with flammability plenum requirements of NFPA 70 and NFPA 262.
 5. Cable shall withstand a bend radius of 1-inch minimum at a temperature of minus 20 degrees C maximum without jacket or insulation cracking.
 6. Manufacturer and Product: Belden; 7852A.
- B. Type 31, Data Highway Cable, Allen-Bradley “Blue Hose”:
 1. Meet or exceed electrical characteristics of Allen-Bradley Catalog No. 1770-CD.
 2. Approved by Allen-Bradley for use with A-B programmable logic controller systems.
 3. Outer Jacket: Blue PVC.
 4. Shield: 1.35-mil, double-faced aluminum/synthetic polymer, overlapped to provide 100 percent coverage.
 5. Drain: 55 percent tinned copper braid and drain wire.
 6. Dimension: 0.243-inch nominal OD.
 7. Conductors:
 - a. One pair 20 AWG, seven-strand tinned copper.
 - b. Insulation: Polyethylene.
 - c. Color Code: Blue and clear.
 8. Manufacturers:
 - a. Allen-Bradley.
 - b. Belden.
- C. Type 32, DeviceNet Round Cable, 600V, Class 1, Two Twisted, Shielded Pairs with Common Overall Shield:
 1. Outer Jacket: PVC.
 2. Overall Shield: Tinned copper braid, 18 AWG tinned copper drain wire.
 3. Individual Pair Shield: Aluminum foil-polyester tape.

4. Dimension: 0.460-inch nominal OD.
 5. Conductors:
 - a. 15 AWG stranded tinned copper.
 - b. Insulation: FEP.
 6. Manufacturer and Product: Belden; 7897A.
- D. Type 33, DeviceNet Flat Cable, 600V, Class 1, Four Conductor Unshielded Network Trunk Cable:
1. Outer Jacket: Thermoplastic Elastomer (TPE).
 2. Conductors: Four conductor, unshielded, flat configuration.
 3. Manufacturer and Product: Allen-Bradley; 1485C-P1E.
- E. Type 34, Profibus PA Cable, 300V:
1. Outer Jacket: PVC.
 2. Shield: Aluminum foil-polyester tape, 20 AWG tinned copper drain wire.
 3. Dimension: 0.253-inch nominal OD.
 4. Conductors:
 - a. 18 AWG stranded tinned copper.
 - b. Insulation: polyolefin.
 5. Manufacturer and Product: Belden; 3076F.

2.05 GROUNDING CONDUCTORS

- A. Equipment: Stranded copper with green, Type USE/RHH/RHW-XLPE or THHN/THWN, insulation.
- B. Direct Buried: Bare stranded copper.

2.06 ACCESSORIES FOR CONDUCTORS 600 VOLTS AND BELOW

- A. Tape:
 1. General Purpose, Flame Retardant: 7-mil, vinyl plastic, Scotch Brand 33+, rated for 90 degrees C minimum, meeting requirements of UL 510.
 2. Flame Retardant, Cold and Weather Resistant: 8.5-mil, vinyl plastic, Scotch Brand 88.
 3. Arc and Fireproofing:
 - a. 30-mil, elastomer.
 - b. Manufacturers and Products:
 - 1) 3M; Scotch Brand 77, with Scotch Brand 69 glass cloth tapebinder.
 - 2) Plymouth; 53 Plyarc, with 77 Plyglas glass cloth tapebinder.

B. Identification Devices:

1. Sleeve:
 - a. Permanent, PVC, yellow or white, with legible machine-printed black markings.
 - b. Manufacturers and Products:
 - 1) Raychem; Type D-SCE or ZH-SCE.
 - 2) Brady, Type 3PS.
2. Heat Bond Marker:
 - a. Transparent thermoplastic heat bonding film with acrylic pressure sensitive adhesive.
 - b. Self-laminating protective shield over text.
 - c. Machine printed black text.
 - d. Manufacturer and Product: 3M Co.; Type SCS-HB.
3. Marker Plate: Nylon, with legible designations permanently hot stamped on plate.
4. Tie-On Cable Marker Tags:
 - a. Chemical-resistant white tag.
 - b. Size: 1/2 inch by 2 inches.
 - c. Manufacturer and Product: Raychem; Type CM-SCE.
5. Grounding Conductor: Permanent green heat-shrink sleeve, 2-inch minimum.

C. Connectors and Terminations:

1. Nylon, Self-Insulated Crimp Connectors:
 - a. Manufacturers and Products:
 - 1) Thomas & Betts; Sta-Kon.
 - 2) Burndy; Insulug.
 - 3) ILSCO.
2. Nylon, Self-Insulated, Crimp Locking-Fork, Torque-Type Terminator:
 - a. Suitable for use with 75 degrees C wire at full NFPA 70, 75 degrees C ampacity.
 - b. Seamless.
 - c. Manufacturers and Products:
 - 1) Thomas & Betts; Sta-Kon.
 - 2) Burndy; Insulink.
 - 3) ILSCO; ILSCONS.
3. Self-Insulated, Freespring Wire Connector (Wire Nuts):
 - a. UL 486C.
 - b. Plated steel, square wire springs.
 - c. Manufacturers and Products:
 - 1) Thomas & Betts.
 - 2) Ideal; Twister.

4. Self-Insulated, Set Screw Wire Connector:
 - a. Two piece compression type with set screw in brass barrel.
 - b. Insulated by insulator cap screwed over brass barrel.
 - c. Manufacturers:
 - 1) 3M Co.
 - 2) Thomas & Betts.
 - 3) Marrette.

D. Cable Lugs:

1. In accordance with NEMA CC 1.
2. Rated 600 volts of same material as conductor metal.
3. Uninsulated Crimp Connectors and Terminators:
 - a. Suitable for use with 75 degrees C wire at full NFPA 70, 75 degrees C ampacity.
 - b. Manufacturers and Products:
 - 1) Thomas & Betts; Color-Keyed.
 - 2) Burndy; Hydent.
 - 3) ILSCO.
4. Uninsulated, Bolted, Two-Way Connectors and Terminators:
 - a. Manufacturers and Products:
 - 1) Thomas & Betts; Locktite.
 - 2) Burndy; Quiklug.
 - 3) ILSCO.

E. Cable Ties:

1. Nylon, adjustable, self-locking, and reusable.
2. Manufacturer and Product: Thomas & Betts; TY-RAP.

F. Heat Shrinkable Insulation:

1. Thermally stabilized cross-linked polyolefin.
2. Single wall for insulation and strain relief.
3. Dual Wall, adhesive sealant lined, for sealing and corrosion resistance.
4. Manufacturers and Products:
 - a. Thomas & Betts; SHRINK-KON.
 - b. Raychem; RNF-100 and ES-2000.

2.07 ACCESSORIES FOR CONDUCTORS ABOVE 600 VOLTS

A. Molded Splice Kits:

1. Components necessary to provide insulation, metallic shielding and grounding systems, and overall jacket.
2. Capable of making splices with a current rating equal to, or greater than cable ampacity, conforming to IEEE 404.

3. Class 5 kV, with compression connector, EPDM molded semiconductive insert, peroxide-cured EPDM insulation, and EPDM molded semiconductive outer shield.
4. Premolded splice shall be re-jacketed with a heat shrinkable adhesive-lined sleeve to provide a waterproof seal.
5. Manufacturers:
 - a. Elastimold.
 - b. Cooper Industries.

B. Heat Shrinkable Splice Kits:

1. Components necessary to provide insulation, metallic shielding and grounding systems, and overall jacket.
2. Capable of making splices with a current rating equal to, or greater than, cable ampacity, conforming to IEEE 404.
3. Class 5 kV, with compression connector, splice insulating and conducting sleeves, stress-relief materials, shielding braid and mesh, and abrasion-resistant heat shrinkable adhesive-lined re-jacketing sleeve to provide a waterproof seal.
4. Manufacturers:
 - a. Raychem.
 - b. 3M Co.

C. Termination Kits:

1. Capable of terminating 5 kV, single-conductor, polymeric-insulated shielded cables plus a shield ground clamp.
2. Capable of producing a termination with a current rating equal to, or greater than, cable ampacity meeting Class 1 requirements of IEEE 48.
3. Capable of accommodating cable shielding or construction without need for special adapters or accessories.
4. Manufacturers:
 - a. Raychem.
 - b. 3M Co.

D. Bus Connection Insulation:

1. Heat shrinkable tubing, tape, and sheets of flexible cross-linked polymeric material formulated for high dielectric strength.
2. Tape and sheet products to have coating to prevent adhesion to metal surfaces.
3. Manufacturer: Raychem.

- E. Cable Lugs:
 - 1. In accordance with NEMA CC1.
 - 2. Rated 5 kV of same material as conductor metal.
 - 3. Manufacturers and Products, Uninsulated Compression Connectors and Terminators:
 - a. Burndy; Hydent.
 - b. Thomas & Betts; Color-Keyed.
 - c. ILSCO.
 - 4. Manufacturers and Products, Uninsulated, Bolted, Two-Way Connectors and Terminators:
 - a. Thomas & Betts; Locktite.
 - b. ILSCO.

2.08 PULLING COMPOUND

- A. Nontoxic, noncorrosive, noncombustible, nonflammable, water-based lubricant; UL listed.
- B. Suitable for rubber, neoprene, PVC, polyethylene, hypalon, CPE, and lead-covered wire and cable.
- C. Approved for intended use by cable manufacturer.
- D. Suitable for zinc-coated steel, aluminum, PVC, bituminized fiber, and fiberglass raceways.
- E. Manufacturers:
 - 1. Ideal Co.
 - 2. Polywater, Inc.
 - 3. Cable Grip Co.

2.09 MANUFACTURED WIRING SYSTEMS

- A. System Rating:
 - 1. 20 amperes load-carrying capacity each phase with final assemblies consisting of maximum of three-phase conductors.
 - 2. Composition: Type MC cable with 90 degrees C insulation and stranded copper conductors.
- B. Cable Configuration: Three, single-phase, five-wire circuit with standard color wire coding:
 - 1. 208/120 Volt: Black, red, blue, white, green.
 - 2. 480/277 Volt: Brown, orange, yellow, white, green.
- C. Locking Mechanism: Latch/strike with voltage clearly marked on latch.

- D. NFPA 262 listed for use in air handling plenums, listed to connect or disconnect under load, and manufactured in accordance with NFPA 70, Article No. 604.

2.10 WARNING TAPE

- A. As specified in Section 26 05 33, Raceway and Boxes.

2.11 SOURCE QUALITY CONTROL

- A. Conductors 600 Volts and Below: Test in accordance with UL 44 and UL 854.
- B. Conductors Above 600 Volts: Test in accordance with NEMA WC 71 and AEIC CS 8 partial discharge level test for EPR insulated cable.

PART 3 EXECUTION

3.01 GENERAL

- A. Conductor installation shall be in accordance with manufacturer's recommendations.
- B. Conductor and cable sizing shown is based on copper conductors, unless noted otherwise.
- C. Do not exceed cable manufacturer's recommendations for maximum pulling tensions and minimum bending radii.
- D. Terminate conductors and cables, unless otherwise indicated.
- E. Tighten screws and terminal bolts in accordance with UL 486A-486B for copper conductors.
- F. Cable Lugs: Provide with correct number of holes, bolt size, and center-to-center spacing as required by equipment terminals.
- G. Bundling: Where single conductors and cables in manholes, handholes, vaults, cable trays, and other indicated locations are not wrapped together by some other means, bundle conductors from each conduit throughout their exposed length with cable ties placed at intervals not exceeding 12 inches on center.
- H. Ream, remove burrs, and clear interior of installed conduit before pulling wires or cables.
- I. Concrete-Encased Raceway Installation: Prior to installation of conductors, pull through each raceway a mandrel approximately 1/4 inch smaller than raceway inside diameter.

J. Cable Tray Installation:

1. Install wire and cable parallel and straight in tray.
2. Bundle, in groups, wire and cable of same voltage having a common routing and destination; use cable ties, at maximum intervals of 8 feet.
3. Clamp cable bundles prior to making end termination connections.
4. Fasten wires, cables, and bundles to tray with nylon cable straps at the following maximum intervals:
 - a. Horizontal Runs: 20 feet.
 - b. Vertical Runs: 5 feet.

K. Installation Requirements:

1. These requirements shall be used when submitting the conduit and wire schedule to be submitted in Section 26 05 02, Basic Electrical Requirements.
2. Some conduit and wire sizes are shown on the Drawings. When shown, these are minimum size assuming only three current carrying conductors per conduit. All power conduits with more than three current carrying conductors shall be sized at least one size larger than as required by the NEC. All other conduits including but not limited to control conduits, instrumentation conduits, telephone conduits, network conduits, etc., shall also be sized one size larger than required by NEC as a minimum. All control conduits with more than 30 control wires shall be two sizes larger than required by the NEC for future use. Installing up to three circuits may be allowed in one conduit providing derating, voltage drop, and conduit fill calculations are submitted for approval and the Owner approves combining the circuits. Contractor shall assume a separate conduit for each circuit for bidding purposes.
3. Install an unspliced ground wire in each conduit. Ground wires cannot have wire nuts or terminals in remote junction boxes; ground wire shall be continuous from the panelboard or control panel to the field device. Install a ground wire for each field device, control panel, etc. Multiple grounds will need to be installed in a conduit depending on how many field devices, control panels, etc., feed. This requirement applies for all types of wiring.
4. Each different wire type specified and shown below shall be in separate conduits and not combined:
 - a. 15 kV.
 - b. 5 kV.
 - c. 480 V.
 - d. 120 V.
 - e. Control (120V ac).
 - f. Instrumentation.
 - g. Telephone.
 - h. DNP Communication & RS-485.
 - i. DeviceNet.

- j. RTD.
- k. Thermocouple.
- l. AFD motor.
- m. Fiber optic.
- n. Vibration sensors.
- o. Control (24V dc).

For example, control wiring and power wiring to a motor shall be in separate conduits even though it may be allowed in accordance with NEC. If a field device and/or control panel requires 480-volt power, 120-volt power, control and instrumentation, then four separate conduits would need to be installed to the device. If multiple devices are in close proximity, the same wire type could be combined for each while complying with all other requirements.

L. Installation Procedures:

1. Where an empty conduit system is indicated, the Contractor shall provide a nylon pull line in the conduit with a 12-inch length of line coiled at each end, in each box.
2. Conduit run exposed or concealed above suspended ceilings shall run parallel with building lines using approved bends or pull boxes where conduits change direction.
3. No conduits will be allowed to be concealed in floor slabs and walls unless shown otherwise on the Drawings.
4. All exposed conduits in single or parallel runs shall be same type and finish.
5. Conduit shall be pitched to drain towards pull boxes or installed to avoid trapping moisture.
6. No conduit shall have more than three 90-degree bends, or the equivalent thereof, between pulling points.
7. Bends shall be carefully made to prevent distortion of circular cross section of conduit and shall have an inside radius of not less than 9 diameters.
 - a. Approved factory elbows shall be used when sharper bends are necessary.
 - b. Conduit shall be sized to permit cable bending radius of at least 8 times cable diameter within elbow.
8. Joining and bending of Type 40 heavy-wall PVC conduit shall be in accordance with manufacturer's recommendations or as approved.
9. Conduits shall be electrically continuous from the point of origin to point of termination and at all intermediate junction points. Effectively ground raceways by connection to properly grounded enclosures, bonding, or other approved means, to obtain permanent low-resistance path to ground throughout installation.
10. Locknuts and bushings shall be used when threaded-type outlet boxes are not used.

11. All connections to field mounted instruments and other equipment subject to vibration, removal for maintenance, or which require adjustment of position shall be made with short lengths of flexible liquid-tight steel conduit not over 18 inches long unless otherwise approved.
 12. Ends of conduit shall be reamed to remove burrs; running threads prohibited on conduit for connection at couplings. Install bushing to protect wire from abrasion unless design of box or fitting affords equivalent protection. Use insulated bushings as necessary.
 13. All screwed joints shall be watertight. Paint threaded ends of steel conduits with an approved joint compound prior to making connections.
 14. Conduit terminations used on PVC jacketed conduit at boxes, cabinets and equipment shall be coated with liquid PVC.
 15. Terminations used with Type 40 heavy-wall PVC conduit shall be made with plastic-to-steel threaded fittings as required.
 16. Pulling points on straight conduit runs shall not exceed 150 feet in length.
 17. Conduits entering galleries or buildings shall be sealed at last accessible box or fitting outside gallery or building.
- M. Comply with NECA Installation Standards.
- N. Crushed or deformed raceways not permitted.
- O. Maintain raceway entirely free of obstructions and moisture.
- P. Immediately after installation, plug or cap raceway ends with watertight and dust-tight seals until time for pulling in conductors.
- Q. Aluminum Conduit: Do not install in direct contact with concrete. Install in PVC sleeve or cored hole through concrete walls and slabs.
- R. Sealing Fittings: Provide drain seal in vertical raceways where condensate may collect above sealing fitting.
- S. Avoid moisture traps where possible. When unavoidable in exposed conduit runs, provide junction box and drain fitting at conduit low point.
- T. Group raceways installed in same area.
- U. Proximity to Heated Piping: Install raceways minimum 12 inches from parallel runs.
- V. Follow structural surface contours when installing exposed raceways. Avoid obstruction of passageways.

- W. Run exposed raceways parallel or perpendicular to walls, structural members, or intersections of vertical planes.
- X. Block Walls: Do not install raceways in same horizontal course or vertical cell with reinforcing steel.
- Y. Install watertight fittings in outdoor, underground, or wet locations.
- Z. Paint threads and cut ends, before assembly of fittings, galvanized conduit, PVC-coated galvanized conduit, or IMC installed in exposed or damp locations with zinc-rich paint or liquid galvanizing compound.
- AA. Metal conduit shall be reamed, burrs removed, and cleaned before installation of conductors, wires, or cables.
- BB. Do not install raceways in concrete equipment pads, foundations, or beams without Engineer approval.
- CC. Horizontal raceways installed under floor slabs shall lie completely under slab, with no part embedded within slab.
- DD. Install concealed, embedded, and buried raceways so that they emerge at right angles to surface and have no curved portion exposed.
- EE. Install conduits for fiber optic cables, telephone cables, and Category 6 data cables in strict conformance with the requirements of TIA 569B.
- FF. Reused Existing Conduits Only Where Shown on Drawings:
 - 1. Pull rag swab through conduits to remove water and to clean conduit prior to installing new cable.
 - 2. Repeat swabbing until all foreign material is removed.
 - 3. Pull mandrel through conduit, if necessary, to remove obstructions.

3.02 POWER CONDUCTOR COLOR CODING

- A. Conductors 600 Volts and Below:
 - 1. 6 AWG and Larger: Apply general purpose, flame retardant tape at each end, and at accessible locations wrapped at least six full overlapping turns, covering area 1-1/2 inches to 2 inches wide.
 - 2. 8 AWG and Smaller: Provide colored conductors.

3. Colors:

| System | Conductor | Color |
|--|---|------------------------------------|
| All Systems | Equipment Grounding | Green |
| 240/120 Volts, Single-Phase, Three-Wire | Grounded Neutral One Hot Leg Other Hot Leg | White Black Red |
| 208Y/120 Volts, Three-Phase, Four-Wire | Grounded Neutral Phase A Phase B Phase C | White Black Red Blue |
| 240/120 Volts, Three-Phase, Four-Wire, Delta, Center Tap, Ground on Single-Phase | Grounded Neutral Phase A High (wild) Leg Phase C | White Black Orange Blue |
| 480Y/277 Volts, Three-Phase, Four-Wire | Grounded Neutral Phase A Phase B Phase C | White Brown Orange Yellow |
| Note: Phase A, B, C implies direction of positive phase rotation. | | |

4. Tracer: Outer covering of white with identifiable colored strip, other than green, in accordance with NFPA 70.

B. Conductors Above 600 Volts:

1. Apply general purpose, flame retardant tape at each end, and at accessible locations wrapped at least six full overlapping turns, covering area 1-1/2 inches to 2 inches wide.
2. Colors:
 - a. Grounded Neutral: White.
 - b. Phase A: Brown.
 - c. Phase B: Orange.
 - d. Phase C: Yellow.

3.03 CIRCUIT IDENTIFICATION

- A. Identify power, instrumentation, and control conductor circuits at each termination, and in accessible locations such as manholes, handholes, panels, switchboards, motor control centers, pull boxes, and terminal boxes.
- B. Circuits Appearing in Circuit Schedules: Identify using circuit schedule designations.

C. Circuits Not Appearing in Circuit Schedules:

1. Assign circuit name based on device or equipment at load end of circuit.
2. Where this would result in same name being assigned to more than one circuit, add number or letter to each otherwise identical circuit name to make it unique.

D. Method:

1. Label each wire at all termination points. Carry individual conductor or circuit identification throughout, with circuit number or the identification clearly stamped on terminal boards and printed on directory cards in distribution cabinets and panelboards.
2. Identify each wire in junction boxes, cabinets, and terminal boxes where total number of control, indicating, and metering wires is three or more and no terminal board is provided, including all power wire by means of plastic split-sleeve, no adhesive, wire marker.
3. In cases similar to above where terminal boards are provided for the control, indicating, and metering wires, identify all wires including motor leads and other power wires too large for connection to terminal boards, by wire markers as specified above.
4. All new, rerouted, or revised wire or cable shall be identified with a wire marker unless otherwise shown or specified.
5. Bare (uninsulated) wire shall not be labeled unless otherwise shown or specified.
6. All wire and cable terminations shall be identified. This includes all lighting and receptacle wiring also. Each wire of a cable shall be identified at all terminations.
7. All wires which are installed in a conduit with a conduit number, as shown on the Drawings, shall be identified with wire markers and shall be numbered consecutively starting with 0001. All wires installed in conduit without a conduit number shall have the circuit number on the wire. For example, a lighting circuit powered from circuit 10 in Panelboard L2 would have L2-10 on all three wires.
8. Wire markers shall be applied to all wires. Wire markers shall be self-laminating white/transparent vinyl film type B-292 by Brady "or-equal." Wire that is 1-inch diameter and less shall be identified with a wire marker, Brady Type DAT-7-292 "or-equal," with a transparent heat shrinking tube over it. Wire that is greater than 1 inch in diameter shall be identified with a wire marker, Brady Type DAT-8-292 "or-equal." The length shall be sufficient to provide at least two and one-half wraps around the wire or cable. All markers shall be machine printed.
9. Wire markers shall be applied to the wire within one-inch of the completed termination and at 24-inch maximum intervals until the wire enters conduit. They shall be applied to cable within 1 inch of cable breakout into individual wires and at 24-inch maximum intervals until the cable enters conduit.

10. All wires and cables installed in cable tray shall have wire markers at a maximum of 20-foot intervals and just before they enter conduit also.

3.04 CONDUCTORS 600 VOLTS AND BELOW

- A. Install 10 AWG or 12 AWG conductors for branch circuit power wiring in lighting and receptacle circuits.
- B. Do not splice incoming service conductors and branch power distribution conductors 6 AWG and larger, unless specifically indicated or approved by Engineer.
- C. Connections and Terminations:
 1. Install wire nuts only on solid conductors. Wire nuts are not allowed on stranded conductors.
 2. Install nylon self-insulated crimp connectors and terminators for instrumentation and control, circuit conductors.
 3. Install self-insulated, set screw wire connectors for two-way connection of power circuit conductors 12 AWG and smaller.
 4. Install uninsulated crimp connectors and terminators for instrumentation, control, and power circuit conductors 4 AWG through 2/0 AWG.
 5. Install uninsulated, bolted, two-way connectors and terminators for power circuit conductors 3/0 AWG and larger.
 6. Install uninsulated terminators bolted together on motor circuit conductors 10 AWG and larger.
 7. Place no more than one conductor in any single-barrel pressure connection.
 8. Install crimp connectors with tools approved by connector manufacturer.
 9. Install terminals and connectors acceptable for type of material used.
 10. Where aluminum conductors are provided, apply oxide-inhibiting compound at joints and terminations.
 11. Compression Lugs:
 - a. Attach with a tool specifically designed for purpose. Tool shall provide complete, controlled crimp and shall not release until crimp is complete.
 - b. Do not use plier type crimpers.
- D. Do not use soldered mechanical joints.
- E. Splices and Terminations:
 1. Insulate uninsulated connections.
 2. Indoors: Use general purpose, flame retardant tape or single wall heat shrink.

3. Outdoors, Dry Locations: Use flame retardant, cold- and weather-resistant tape or single wall heat shrink.
 4. Below Grade and Wet or Damp Locations: Use dual wall heat shrink.
- F. Cap spare conductors with UL listed end caps.
- G. Cabinets, Panels, and Motor Control Centers:
1. Remove surplus wire, bridle and secure.
 2. Where conductors pass through openings or over edges in sheet metal, remove burrs, chamfer edges, and install bushings and protective strips of insulating material to protect the conductors.
- H. Control and Instrumentation Wiring:
1. Where terminals provided will accept such lugs, terminate control and instrumentation wiring, except solid thermocouple leads, with insulated, locking-fork compression lugs.
 2. Terminate with methods consistent with terminals provided, and in accordance with terminal manufacturer's instructions.
 3. Locate splices in readily accessible cabinets or junction boxes using terminal strips.
 4. Where connections of cables installed under this section are to be made under Section 40 90 01, Instrumentation and Control for Process Systems, leave pigtails of adequate length for bundled connections.
 5. Cable Protection:
 - a. Under Infinite Access Floors: May install without bundling.
 - b. All Other Areas: Install individual wires, pairs, or triads in flex conduit under floor or grouped into bundles at least 1/2 inch in diameter.
 - c. Maintain integrity of shielding of instrumentation cables.
 - d. Ensure grounds do not occur because of damage to jacket over shield.
- I. Extra Conductor Length: For conductors to be connected by others, install minimum 6 feet of extra conductor in freestanding panels and minimum 2 feet in other assemblies.

3.05 CONDUCTORS ABOVE 600 VOLTS

- A. Do not splice unless specifically indicated or approved by Engineer.
- B. Make joints and terminations with splice and termination kits, in accordance with kit manufacturer's instructions.
- C. Install splices or terminations as continuous operation in accessible locations under clean, dry conditions.

- D. Single Conductor Cable Terminations: Provide heat shrinkable stress control and outer nontracking insulation tubings, high relative permittivity stress relief mastic for insulation shield cutback treatment, and a heat-activated sealant for environmental sealing, plus a ground braid and clamp.
- E. Install terminals or connectors acceptable for type of conductor material used.
- F. Provide shield termination and grounding for terminations.
- G. Provide necessary mounting hardware, covers, and connectors.
- H. Connections and Terminations:
 - 1. Install uninsulated crimp connectors and terminators for power circuit conductors 4 AWG and larger.
 - 2. Install uninsulated, bolted, two-way connectors for motor circuit conductors No. 12 and larger.
 - 3. Insulate bus connections with heat shrinking tubing, tape, and sheets.
- I. Give 2 working days notice to Engineer prior to making splices or terminations.

3.06 CONDUCTOR ARC AND FIREPROOFING

- A. Install arc and fireproofing tape on 600-volt single conductors and cables, except those rated Type TC throughout entire exposed length at splices in manholes, handholes, vaults, cable trays, and other indicated locations.
- B. Install arc and fireproofing tape on 5 kV cables throughout entire exposed length at splices in manholes, handholes, vaults, cable trays, and other indicated locations.
- C. Wrap conductors of same circuit entering from separate conduit together as single cable.
- D. Follow tape manufacturer's installation instructions.
- E. Secure tape at intervals of 5 feet with bands of tapebinder. Each band to consist of a minimum of two wraps directly over each other.

3.07 BUSWAY

- A. Install in strict accordance with manufacturer's recommendations and NFPA 70.
- B. Maximum Support Spacing: 10 feet.

END OF SECTION

SECTION 26 05 26
GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

PART 1 GENERAL

1.01 REFERENCES

- A. The following is a list of standards which may be referenced in this section:
1. Institute of Electrical and Electronics Engineers (IEEE): C2, National Electrical Safety Code (NESC).
 2. National Fire Protection Association (NFPA): 70, National Electrical Code. (NEC).

1.02 SUBMITTALS

- A. Action Submittals:
1. Shop Drawings:
 - a. Product data for the following: Exothermic weld connectors.

1.03 QUALITY ASSURANCE

- A. Authority Having Jurisdiction (AHJ):
1. Provide the Work in accordance with NFPA 70, National Electrical Code (NEC). Where required by the AHJ, provide material and equipment labeled or listed by a nationally recognized testing laboratory or other organization acceptable to the AHJ to provide a basis for approval under NEC.
 2. Materials and equipment manufactured within the scope of standards published by UL:
 - a. Confirm conformance with UL standards.
 - b. Supply with an applied UL listing mark.

PART 2 PRODUCTS

2.01 GROUND ROD

- A. Material: Copper.
- B. Diameter: Minimum 1 inch.
- C. Length: 20 feet.

2.02 GROUND CONDUCTORS

- A. As specified in Section 26 05 05, Conductors.

2.03 CONNECTORS

- A. Exothermic Weld Type:

1. Outdoor Weld: Suitable for exposure to elements or direct burial.
2. Indoor Weld: Use low-smoke, low-emission process.
3. Manufacturers:
 - a. Erico Products, Inc.; Cadweld and Cadweld Exolon.
 - b. Thermoweld.

- B. Compression Type:

1. Compress-deforming type; wrought copper extrusion material.
2. Single indentation for conductors 6 AWG and smaller.
3. Double indentation with extended barrel for conductors 4 AWG and larger.
4. Barrels prefilled with oxide-inhibiting and antiseizing compound and sealed.
5. Manufacturers:
 - a. Burndy Corp.; Hyground Irreversible Compression.
 - b. Thomas and Betts Co.
 - c. ILSCO.

- C. Mechanical Type: Split-bolt, saddle, or cone screw type; copper alloy material.

1. Manufacturers:
 - a. Burndy Corp.
 - b. Thomas and Betts Co.

2.04 GROUNDING WELLS

- A. Ground rod box complete with cast-iron riser ring and traffic cover marked "GROUND ROD".

- B. Manufacturers and Products:

1. Christy Co.
2. Lightning and Grounding Systems, Inc.

PART 3 EXECUTION

3.01 GENERAL

- A. Grounding: In compliance with NFPA 70 and IEEE C2.
- B. Ground electrical service neutral at service entrance equipment with grounding electrode conductor to grounding electrode system.
- C. Ground each separately derived system neutral with common grounding electrode conductor to grounding electrode system.
- D. Bond together all grounding electrodes that are present at each building or structure served to form one common grounding electrode system.
- E. Bond together system neutrals, service equipment enclosures, exposed noncurrent-carrying metal parts of electrical equipment, metal raceways, ground conductor in raceways and cables, receptacle ground connections, and metal piping systems.
- F. Shielded Power Cables: Ground shields at each splice or termination in accordance with recommendations of splice or termination manufacturer.
- G. Shielded Instrumentation Cables:
 - 1. Ground shield to ground bus at power supply for analog signal.
 - 2. Expose shield minimum 1 inch at termination to field instrument and apply heat shrink tube.
 - 3. Do not ground instrumentation cable shield at more than one point.

3.02 WIRE CONNECTIONS

- A. Ground Conductors: Install in conduit containing power conductors and control circuits above 50 volts.
- B. Nonmetallic Raceways and Flexible Tubing: Install equipment grounding conductor connected at both ends to noncurrent-carrying grounding bus.
- C. Connect ground conductors to raceway grounding bushings.
- D. Extend and connect ground conductors to ground bus in all equipment containing a ground bus.
- E. Connect enclosure of equipment containing ground bus to that bus.
- F. Bolt connections to equipment ground bus.

- G. Bond grounding conductors to metallic enclosures at each end, and to intermediate metallic enclosures.
- H. Junction Boxes: Furnish materials and connect to equipment grounding system with grounding clips mounted directly on box, or with 3/8-inch machine screws.
- I. Metallic Equipment Enclosures: Use furnished ground lug; if none furnished, tap equipment housing and install solderless terminal connected to box with machine screw. For circuits greater than 20 amps use minimum 5/16-inch diameter bolt.

3.03 MOTOR GROUNDING

- A. Extend equipment ground bus via grounding conductor installed in motor feeder raceway; connect to motor frame.
- B. Nonmetallic Raceways and Flexible Tubing: Install an equipment grounding conductor connected at both ends to noncurrent-carrying grounding bus.
- C. Motors Less Than 10 hp: Use furnished ground lug in motor connection box. If none furnished, provide compression, spade-type terminal connected to conduit box mounting screw.
- D. Motors 10 hp and Above: Use furnished ground lug in motor connection box. If none furnished, tap motor frame or equipment housing; furnish compression, one-hole, lug type terminal connected with minimum 5/16-inch brass threaded stud with bolt and washer.
- E. Circuits 20 Amps or Above: Tap motor frame or equipment housing. Install solderless terminal with minimum 5/16-inch diameter bolt.

3.04 GROUND RODS

- A. Install full length with conductor connection at upper end.
- B. Install with connection point below finished grade, unless otherwise shown.
- C. Space multiple ground rods by one rod length.
- D. Install to 8 feet below local frost depth.

3.05 GROUNDING WELLS

- A. Install for ground rods located inside buildings, asphalt and paved areas, and where shown on Drawings.
- B. Install riser ring and cover flush with surface.
- C. Place 12 inches of crushed rock in bottom of each well.

3.06 CONNECTIONS

A. General:

- 1. Abovegrade Connections: Install exothermic weld, mechanical, or compression-type connectors; or brazing.
- 2. Belowgrade Connections: Install exothermic weld or compression type connectors.
- 3. Remove paint, dirt, or other surface coverings at connection points to allow good metal-to-metal contact.
- 4. Notify Engineer prior to backfilling ground connections.

B. Exothermic Weld Type:

- 1. Wire brush or file contact point to bare metal surface.
- 2. Use welding cartridges and molds in accordance with manufacturer's recommendations.
- 3. Avoid using badly worn molds.
- 4. Mold to be completely filled with metal when making welds.
- 5. After completed welds have cooled, brush slag from weld area and thoroughly clean joint.

C. Compression Type:

- 1. Install in accordance with connector manufacturer's recommendations.
- 2. Install connectors of proper size for grounding conductors and ground rods specified.
- 3. Install using connector manufacturer's compression tool having proper sized dies and operate per manufacturer's instructions.

D. Mechanical Type:

- 1. Apply homogeneous blend of colloidal copper and rust and corrosion inhibitor before making connection.
- 2. Install in accordance with connector manufacturer's recommendations.
- 3. Do not conceal mechanical connections.

3.07 METAL STRUCTURE GROUNDING

- A. Bond metal sheathing and exposed metal vertical structural elements to grounding system.
- B. Bond electrical equipment supported by metal platforms to the platforms.
- C. Provide electrical contact between metal frames and railings supporting pushbutton stations, receptacles, and instrument cabinets, and raceways carrying circuits to these devices.

3.08 TRANSFORMER GROUNDING

- A. Bond neutrals of transformers within buildings to system ground network and to any additional indicated grounding electrodes.
- B. Bond neutrals of substation transformers to substation grounding grid and system grounding network.
- C. Bond neutrals of pad-mounted transformers to four locally driven ground rod and system ground network.

3.09 LIGHTNING PROTECTION SYSTEMS

- A. Bond lightning protection system ground terminals to building or structure grounding electrode system.

3.10 SURGE PROTECTION EQUIPMENT GROUNDING

- A. Connect surge arrestor ground terminals to equipment ground bus.

END OF SECTION

**SECTION 26 05 33
RACEWAY AND BOXES**

PART 1 GENERAL

1.01 REFERENCES

- A. The following is a list of standards which may be referenced in this section:
1. American Association of State Highway and Transportation Officials (AASHTO): HB, Standard Specifications for Highway Bridges.
 2. ASTM International (ASTM):
 - a. A123/123M, Standard Specification for Zinc (Hot-Dipped Galvanized) Coatings on Iron and Steel Products.
 - b. A167, Standard Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip.
 - c. A240/A240M, Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications.
 - d. C857, Standard Practice for Minimum Structural Design Loading for Underground Precast Concrete Utility Structures.
 - e. D149, Standard Test Method for Dielectric Breakdown Voltage and Dielectric Strength of Solid Electrical Insulating Materials at Commercial Power Frequencies.
 3. Telecommunications Industry Association (TIA): 569B, Commercial Building Standard for Telecommunications Pathways and Spaces.
 4. National Electrical Contractor's Association, Inc. (NECA): Installation standards.
 5. National Electrical Manufacturers Association (NEMA):
 - a. 250, Enclosures for Electrical Equipment (1000 Volts Maximum).
 - b. C80.1, Electrical Rigid Steel Conduit (ERSC).
 - c. C80.3, Steel Electrical Metallic Tubing (EMT).
 - d. C80.5, Electrical Rigid Aluminum Conduit (ERAC).
 - e. C80.6, Electrical Intermediate Metal Conduit (EIMC).
 - f. RN 1, Polyvinyl Chloride (PVC) Externally Coated Galvanized Rigid Steel Conduit and Intermediate Metal Conduit.
 - g. TC 2, Electrical Polyvinyl Chloride (PVC) Conduit.
 - h. TC 3, Polyvinyl Chloride (PVC) Fittings for Use with Rigid PVC Conduit and Tubing.
 - i. TC 6, Polyvinyl Chloride (PVC) Plastic Utilities Duct for Underground Installation.
 - j. TC 14, Reinforced Thermosetting Resin Conduit (RTRC) and Fittings.
 - k. VE 1, Metallic Cable Tray Systems.
 6. National Fire Protection Association (NFPA): 70, National Electrical Code (NEC).

7. Underwriters Laboratories Inc. (UL):
 - a. 1, Standard for Safety for Flexible Metal Conduit.
 - b. 5, Standard for Safety for Surface Metal Raceways and Fittings.
 - c. 6, Standard for Safety for Electrical Rigid Metal Conduit – Steel.
 - d. 6A, Standard for Safety for Electrical Rigid Metal Conduit – Aluminum, Red Brass and Stainless.
 - e. 360, Standard for Safety for Liquid-Tight Flexible Steel Conduit.
 - f. 514B, Standard for Safety for Conduit, Tubing, and Cable Fittings.
 - g. 651, Standard for Safety for Schedule 40 and 80 Rigid PVC Conduit and Fittings.
 - h. 651A, Standard for Safety for Type EB and A Rigid PVC Conduit and HDPE Conduit.
 - i. 797, Standard for Safety for Electrical Metallic Tubing – Steel.
 - j. 870, Standard for Safety for Wireways, Auxiliary Gutters, and Associated Fittings.
 - k. 1242, Standard for Safety for Electrical Intermediate Metal Conduit – Steel.
 - l. 1660, Standard for Safety for Liquid-Tight Flexible Nonmetallic Conduit.
 - m. 1684, Standard for Safety for Reinforced Thermosetting Resin Conduit (RTRC) and Fittings.
 - n. 2024, Standard for Safety for Optical Fiber and Communication Cable Raceway.

1.02 SUBMITTALS

A. Action Submittals:

1. Manufacturer's Literature:
 - a. Rigid galvanized steel conduit.
 - b. Intermediate metal conduit.
 - c. Rigid aluminum conduit.
 - d. PVC Schedule 40 conduit.
 - e. PVC-coated rigid galvanized steel conduit.
 - f. Flexible metal, liquid-tight conduit.
 - g. Conduit fittings.
 - h. Wireways.
 - i. Surface metal raceway.
 - j. Device boxes for use in hazardous areas.
 - k. Junction and pull boxes used at or below grade.
 - l. Large junction and pull boxes.
 - m. Terminal junction boxes.
2. Equipment and machinery proposed for bending metal conduit.
3. Method for bending PVC conduit less than 30 degrees.
4. Seismic anchorage and bracing drawings and cut sheets, as required by Section 01 88 15, Anchorage and Bracing.

5. Conduit Layout:
 - a. Provide drawings for conduit installations underground and concealed conduits including, but not limited to ductbanks, under floor slabs, concealed in floor slabs, and concealed in walls.
 - b. Provide plan and section showing arrangement and location of conduit and duct bank required for:
 - 1) Low and medium voltage feeder and branch circuits.
 - 2) Instrumentation and control systems.
 - 3) Communications systems.
 - 4) Empty conduit for future use.
 - c. Electronic CAD; scale not greater than 1-inch equals 20 feet.

B. Informational Submittals:

1. Seismic anchorage and bracing calculations as required by Section 01 88 15, Anchorage and Bracing.
2. Manufacturer's certification of training for PVC-coated rigid galvanized steel conduit installer.

1.03 QUALITY ASSURANCE

A. Authority Having Jurisdiction (AHJ):

1. Provide the Work in accordance with NFPA 70, National Electrical Code (NEC). Where required by the AHJ, material and equipment shall be labeled or listed by a nationally recognized testing laboratory or other organization acceptable to the AHJ in order to provide a basis for approval under NEC.
2. Materials and equipment manufactured within scope of standards published by Underwriters Laboratories, Inc. shall conform to those standards and shall have an applied UL listing mark.

- B. PVC-Coated, Rigid Galvanized Steel Conduit Installer: Certified by conduit manufacturer as having received minimum two hours of training on installation procedures.

PART 2 PRODUCTS

2.01 CONDUIT AND TUBING

A. Rigid Galvanized Steel Conduit (RGS):

1. Meet requirements of NEMA C80.1 and UL 6.
2. Material: Hot-dip galvanized with chromated protective layer.

B. Rigid Aluminum Conduit:

1. Meet requirements of NEMA C80.5 and UL 6A.
2. Material: Type 6063, copper-free aluminum alloy.

C. PVC-Coated Rigid Galvanized Steel Conduit:

1. Meet requirements of NEMA RN 1 and ETL.
2. Material:
 - a. Meet requirements of NEMA C80.1 and UL 6.
 - b. Exterior Finish: PVC coating, 40-mil nominal thickness; bond to metal shall have tensile strength greater than PVC.
 - c. Interior finish: Urethane coating, 2-mil nominal thickness.
3. Threads: Hot-dipped galvanized and factory coated with urethane.
4. Bendable without damage to interior or exterior coating.

D. Flexible Metal, Liquid-Tight Conduit:

1. UL 360 listed for 105 degrees C insulated conductors.
2. Material: Galvanized steel with extruded PVC jacket.

2.02 FITTINGS

A. Rigid Galvanized Steel and Intermediate Metal Conduit:

1. General:
 - a. Meet requirements of UL 514B.
 - b. Type: Threaded, galvanized. Set screw and threadless compression fittings not permitted.
2. Bushing:
 - a. Material: Malleable iron with integral insulated throat, rated for 150 degrees C.
 - b. Manufacturers and Products:
 - 1) Appleton; Series BU-I.
 - 2) O-Z/Gedney; Type HB.
3. Grounding Bushing:
 - a. Material: Malleable iron with integral insulated throat rated for 150 degrees C, with solderless lugs.
 - b. Manufacturers and Products:
 - 1) Appleton; Series GIB.
 - 2) O-Z/Gedney; Type HBLG.
4. Conduit Hub:
 - a. Material: Malleable iron with insulated throat with bonding screw.
 - b. UL listed for use in wet locations.
 - c. Manufacturers and Products:
 - 1) Appleton, Series HUB-B.
 - 2) O-Z/Gedney; Series CH.
 - 3) Meyers; ST Series.

5. Conduit Bodies:
 - a. Sized as required by NFPA 70.
 - b. Manufacturers and Products (For Normal Conditions):
 - 1) Appleton; Form 35 threaded unilets.
 - 2) Crouse-Hinds; Form 7 or Form 8 threaded condulets.
 - 3) Killark; Series O electrolets.
 - 4) Thomas & Betts; Form 7 or Form 8.
 - c. Manufacturers (For Hazardous Locations):
 - 1) Appleton.
 - 2) Crouse-Hinds.
 - 3) Killark.
6. Couplings: As supplied by conduit manufacturer.
7. Unions:
 - a. Concrete tight, hot-dip galvanized malleable iron.
 - b. Manufacturers and Products:
 - 1) Appleton; Series SCC bolt-on coupling or Series EC three-piece union.
 - 2) O-Z/Gedney; Type SSP split coupling or Type 4 Series, three-piece coupling.
8. Conduit Sealing Fitting:
 - a. Manufacturers and Products:
 - 1) Appleton; Type EYF, EYM, or ESU.
 - 2) Crouse-Hinds; Type EYS or EZS.
 - 3) Killark; Type EY or Type EYS.
9. Drain Seal:
 - a. Manufacturers and Products:
 - 1) Appleton; Type EYD.
 - 2) Crouse-Hinds; Type EYD or Type EZD.
10. Drain/Breather Fitting:
 - a. Manufacturers and Products:
 - 1) Appleton; Type ECDB.
 - 2) Crouse-Hinds; ECD.
11. Expansion Fitting:
 - a. Manufacturers and Products:
 - 1) Deflection/Expansion Movement:
 - a) Appleton; Type DF.
 - b) Crouse-Hinds; Type XD.
 - 2) Expansion Movement Only:
 - a) Appleton; Type XJ.
 - b) Crouse-Hinds; Type XJ.
 - c) Thomas & Betts; XJG-TP.
12. Cable Sealing Fitting:
 - a. To form watertight nonslip cord or cable connection to conduit.
 - b. For Conductors with OD of 1/2 inch or Less: Neoprene bushing at connector entry.
 - c. Manufacturers and Products:
 - 1) Appleton; CG-S.
 - 2) Crouse-Hinds; CGBS.

B. Rigid Aluminum Conduit:

1. General:
 - a. Meet requirements of UL 514B.
 - b. Type: Threaded, copper-free. Set screw fittings not permitted.
2. Insulated Bushing:
 - a. Material: Cast aluminum, with integral insulated throat, rated for 150 degrees C.
 - b. Manufacturer and Product: O-Z/Gedney; Type AB.
3. Grounding Bushing:
 - a. Material: Cast aluminum with integral insulated throat, rated for 150 degrees, with solderless lugs.
 - b. Manufacturer and Product: O-Z/Gedney; Type ABLG.
4. Conduit Hub:
 - a. Material: Cast aluminum, with insulated throat.
 - b. UL listed for use in wet locations.
 - c. Manufacturers and Products:
 - 1) O-Z/Gedney; Type CHA.
 - 2) Thomas & Betts; Series 370AL.
 - 3) Meyers; Series SA.
5. Conduit Bodies:
 - a. Manufacturers and Products (For Normal Conditions):
 - 1) Appleton; Form 85 threaded unilets.
 - 2) Crouse-Hinds; Mark 9 or Form 7-SA threaded condulets.
 - 3) Killark; Series O electrolets.
 - b. Manufacturers (For Hazardous Locations):
 - 1) Appleton.
 - 2) Crouse-Hinds.
 - 3) Killark.
6. Couplings: As supplied by conduit manufacturer.
7. Conduit Sealing Fitting:
 - a. Manufacturers and Products:
 - 1) Appleton; Type EYF-AL or EYM-AL.
 - 2) Crouse-Hinds; Type EYS-SA or EZS-SA.
 - 3) Killark; Type EY or Type EYS.
8. Drain Seal:
 - a. Manufacturers and Products:
 - 1) Appleton; Type EYDM-A.
 - 2) Crouse-Hinds; Type EYD-SA or Type EZD-SA.
9. Drain/Breather Fitting:
 - a. Manufacturers and Products:
 - 1) Appleton; Type ECDB.
 - 2) Crouse-Hinds; ECD.
10. Expansion Fitting:
 - a. Manufacturers and Products:
 - 1) Deflection/Expansion Movement: Steel City; Type DF-A.
 - 2) Expansion Movement Only: Steel City; Type AF-A.

11. Cable Sealing Fittings:
 - a. To form watertight nonslip cord or cable connection to conduit.
 - b. Bushing: Neoprene at connector entry.
 - c. Manufacturer and Product: Appleton; CG-S.

- C. PVC-Coated Rigid Galvanized Steel Conduit:
 1. Meet requirements of UL 514B.
 2. Fittings: Rigid galvanized steel type, PVC coated by conduit manufacturer.
 3. Conduit Bodies: Cast metal hot-dipped galvanized or urethane finish. Cover shall be of same material as conduit body. PVC coated by conduit manufacturer.
 4. Finish: 40-mil PVC exterior, 2-mil urethane interior.
 5. Overlapping pressure-sealing sleeves.
 6. Conduit Hangers, Attachments, and Accessories: PVC-coated.
 7. Manufacturers:
 - a. Robroy Industries.
 - b. Ocal.
 8. Expansion Fitting:
 - a. Manufacturer and Product: Ocal; OCAL-BLUE XJG.

- D. Flexible Metal, Liquid-Tight Conduit:
 1. Metal insulated throat connectors with integral nylon or plastic bushing rated for 105 degrees C.
 2. Insulated throat and sealing O-rings.
 3. Manufacturers and Products:
 - a. Thomas & Betts; Series 5331.
 - b. O-Z/Gedney; Series 4Q.

- E. Flexible Coupling, Hazardous Locations:
 1. Approved for use in atmosphere involved.
 2. Rating: Watertight and UL listed for use in Class I, Division 1 and 2 areas.
 3. Outer bronze braid and an insulating liner.
 4. Conductivity equal to a similar length of rigid metal conduit.
 5. Manufacturers and Products:
 - a. Crouse-Hinds; Type ECGJH or Type ECLK.
 - b. Appleton; EXGJH or EXLK.

- F. Watertight Entrance Seal Device:
1. New Construction:
 - a. Material: Oversized sleeve, malleable iron body with sealing ring, pressure ring, grommet seal, and pressure clamp.
 - b. Manufacturer and Product: O-Z/Gedney; Type FSK or Type WSK, as required.
 2. Cored-Hole Application:
 - a. Material: Assembled dual pressure disks, neoprene sealing ring, and membrane clamp.
 - b. Manufacturer and Product: O-Z/Gedney; Series CSM.

2.03 OUTLET AND DEVICE BOXES

- A. Sheet Steel: One-piece drawn type, zinc-plated or cadmium-plated.
- B. Cast Metal:
1. Box: Malleable iron or cast ferrous metal.
 2. Cover: Gasketed, weatherproof, malleable iron, with stainless steel screws.
 3. Hubs: Threaded.
 4. Lugs: Cast Mounting.
 5. Manufacturers and Products, Nonhazardous Locations:
 - a. Crouse-Hinds; Type FS or Type FD.
 - b. Appleton; Type FS or Type FD.
 - c. Killark.
 6. Manufacturers and Products, Hazardous Locations:
 - a. Crouse-Hinds; Type GUA or Type EAJ.
 - b. Appleton; Type GR.
- C. Cast Aluminum:
1. Material:
 - a. Box: Cast, copper-free aluminum.
 - b. Cover: Gasketed, weatherproof, cast copper-free aluminum with stainless steel screws.
 2. Hubs: Threaded.
 3. Lugs: Cast mounting.
 4. Manufacturers and Products, Nonhazardous Locations:
 - a. Crouse-Hinds; Type FS-SA or Type FD-SA.
 - b. Appleton; Type FS or Type FD.
 - c. Killark.
 5. Manufacturers and Products, Hazardous Locations:
 - a. Crouse-Hinds; Type GUA-SA.
 - b. Appleton; Type GR.

D. PVC-Coated Cast Metal:

1. Type: One-piece.
2. Material: Malleable iron, cast ferrous metal, or cast aluminum.
3. Coating:
 - a. Exterior Surfaces: 40-mil PVC.
 - b. Interior Surfaces: 2-mil urethane.
4. Manufacturers:
 - a. Robroy Industries.
 - b. Ocal.

2.04 JUNCTION AND PULL BOXES

A. Outlet Box Used as Junction or Pull Box: As specified under Article Outlet and Device Boxes.

B. Conduit Bodies Used as Junction Boxes: As specified under Article Fittings.

C. Large Cast Metal Box:

1. NEMA 250, Type 4.
2. Box: Cast malleable iron, with drilled and tapped conduit entrances and exterior mounting lugs.
3. Cover: Hinged with clamps.
4. Gasket: Neoprene.
5. Hardware and Machine Screws: ASTM A167, Type 316 stainless steel.
6. Manufacturers and Products, Surface Mounted Nonhinged Type:
 - a. Crouse-Hinds; Series W.
 - b. O-Z/Gedney; Series Y.
7. Manufacturer and Product, Surface Mounted, Hinged Type:
O-Z/Gedney; Series YW.
8. Manufacturers and Products, Recessed Type:
 - a. Crouse-Hinds; Type WJBF.
 - b. O-Z/Gedney; Series YR.

D. Large Cast Metal Box, Hazardous Locations:

1. NEMA 250 Type 7 or Type 9 as required for Class, Division, and Group involved.
2. Box: Cast ferrous metal, electro-galvanize finished or copper-free aluminum with drilled and tapped conduit entrances.
3. Cover: Hinged with screws.
4. Hardware and Machine Screws: ASTM A167, Type 316 stainless steel.
5. Manufacturers and Products:
 - a. Crouse-Hinds; Type EJB.
 - b. Appleton; Type AJBEW.

E. Large Cast Aluminum Box:

1. NEMA 250 Type 4.
2. Box: Cast copper-free aluminum, with drilled and tapped conduit entrances and exterior mounting lugs.
3. Cover: Nonhinged.
4. Gasket: Neoprene.
5. Hardware and Machine Screws: ASTM A167, Type 316 stainless steel.
6. Manufacturers and Products, Surface Mounted Type:
 - a. Crouse-Hinds; Series W-SA.
 - b. O-Z/Gedney; Series YS-A, YL-A.
 - c. Killark.

F. Large Stainless Steel Box:

1. NEMA 250 Type 4X.
2. Box: 14-gauge, ASTM A240/A240M, Type 304 stainless steel.
3. Cover: Hinged with screws.
4. Hardware and Machine Screws: ASTM A167, Type 316 stainless steel.
5. Manufacturers:
 - a. Hoffman Engineering Co.
 - b. Robroy Industries.
 - c. Wiegman.

2.05 TERMINAL JUNCTION BOX

- A. Cover: Hinged, unless otherwise shown.
- B. Interior Finish: Paint with white enamel or lacquer.
- C. Terminal Blocks:
 1. Separate connection point for each conductor entering or leaving box.
 2. Spare Terminal Points: 25 percent, minimum.

2.06 ACCESSORIES

- A. Identification Devices:
 1. Raceway Tags:
 - a. Material: Laminated plastic.
 - b. Shape: Rectangular.
 - c. Raceway Designation: Engraved.
 - d. White background with 1/4-inch black lettering.
 - e. Attach to conduit with stainless steel straps on the end of each tag.

B. Heat Shrinkable Tubing:

1. Material: Heat-shrinkable, cross-linked polyolefin.
2. Semi-flexible with meltable adhesive inner liner.
3. Color: Black.
4. Manufacturers:
 - a. Raychem.
 - b. 3M.

C. Wraparound Duct Band:

1. Material: Heat-shrinkable, cross-linked polyolefin, precoated with hot-melt adhesive.
2. Width: 50 mm minimum.
3. Manufacturer and Product: Raychem; Type TWDB.

PART 3 EXECUTION

3.01 GENERAL

- A. Conduit and tubing sizes shown are based on use of copper conductors. Reference Section 26 05 05, Conductors, concerning conduit sizing for aluminum conductors.
- B. Comply with NECA Installation Standards.
- C. Crushed or deformed raceways not permitted.
- D. Maintain raceway entirely free of obstructions and moisture.
- E. Immediately after installation, plug or cap raceway ends with watertight and dust-tight seals until time for pulling in conductors.
- F. Aluminum Conduit: Do not install in direct contact with concrete. Install in PVC sleeve or cored hole through concrete walls and slabs.
- G. Sealing Fittings: Provide drain seal in vertical raceways where condensate may collect above sealing fitting.
- H. Avoid moisture traps where possible. When unavoidable in exposed conduit runs, provide junction box and drain fitting at conduit low point.
- I. Group raceways installed in same area.
- J. Proximity to Heated Piping: Install raceways minimum 12 inches from parallel runs.
- K. Follow structural surface contours when installing exposed raceways. Avoid obstruction of passageways.

- L. Run exposed raceways parallel or perpendicular to walls, structural members, or intersections of vertical planes.
- M. Block Walls: Do not install raceways in same horizontal course or vertical cell with reinforcing steel.
- N. Install watertight fittings in outdoor, underground, or wet locations.
- O. Paint threads and cut ends, before assembly of fittings, galvanized conduit, PVC-coated galvanized conduit, or IMC installed in exposed or damp locations with zinc-rich paint or liquid galvanizing compound.
- P. Metal conduit shall be reamed, burrs removed, and cleaned before installation of conductors, wires, or cables.
- Q. Do not install raceways in concrete equipment pads, foundations, or beams without Engineer approval.
- R. Horizontal raceways installed under floor slabs shall lie completely under slab, with no part embedded within slab.
- S. Install concealed, embedded, and buried raceways so that they emerge at right angles to surface and have no curved portion exposed.
- T. Install conduits for fiber optic cables, telephone cables, and Category 6 data cables in strict conformance with the requirements of TIA 569B.

3.02 CONDUIT APPLICATION

- A. Diameter: Minimum 3/4 inch.
- B. Exterior, Exposed: PVC-coated rigid galvanized steel.
- C. Interior, Exposed: PVC-coated rigid galvanized steel.

3.03 FLEXIBLE CONNECTIONS

- A. For motors, wall or ceiling mounted fans and unit heaters, dry type transformers, electrically operated valves, instrumentation, and other locations approved by Engineer where flexible connection is required to minimize vibration:
 1. Conduit Size 4 Inches or Less: Flexible metal, liquid-tight conduit.
 2. Conduit Size Over 4 Inches: Nonflexible.
- B. Suspended Lighting Fixtures in Dry Areas: Flexible steel, nonliquid-tight conduit.
- C. Outdoor Areas, Process Areas Exposed to Moisture, and Areas Required to be Oiltight and Dust-Tight: Flexible metal, liquid-tight conduit.

- D. Flexible Conduit Length: 18 inches minimum, 60 inches maximum; sufficient to allow movement or adjustment of equipment.

3.04 PENETRATIONS

- A. Make at right angles, unless otherwise shown.
- B. Notching or penetration of structural members, including footings and beams, not permitted.
- C. Fire-Rated Walls, Floors, or Ceilings: Firestop openings around penetrations to maintain fire-resistance rating as specified in Section 26 05 04, Basic Electrical Materials and Methods.
- D. Apply heat shrinkable tubing to metallic conduit protruding through concrete floor slabs to a point 2 inches above and 2 inches below concrete surface.
- E. Concrete Walls, Floors, or Ceilings (Aboveground): Provide nonshrink grout dry-pack or use watertight seal device.
- F. Entering Structures:
 - 1. General: Seal raceway at first box or outlet with oakum or expandable plastic compound to prevent entrance of gases or liquids from one area to another.
 - 2. Concrete Roof or Membrane Waterproofed Wall or Floor:
 - a. Provide a watertight seal.
 - b. Without Concrete Encasement: Install watertight entrance seal device on each side.
 - c. With Concrete Encasement: Install watertight entrance seal device on accessible side.
 - d. Securely anchor malleable iron body of watertight entrance seal device into construction with one or more integral flanges.
 - e. Secure membrane waterproofing to watertight entrance seal device in a permanent, watertight manner.
 - 3. Heating, Ventilating, and Air Conditioning Equipment:
 - a. Penetrate equipment in area established by manufacturer.
 - b. Terminate conduit with flexible metal conduit at junction box or conduit attached to exterior surface of equipment prior to penetrating equipment.
 - c. Seal penetration with sealant as specified in Section 03 30 10, Structural Concrete.
 - 4. Corrosive-Sensitive Areas:
 - a. Seal conduit passing through room walls.
 - b. Seal conduit entering equipment panel boards and field panels containing electronic equipment.
 - c. Seal penetration with sealant as specified in Section 03 30 10, Structural Concrete.

5. Existing or Precast Wall (Underground): Core drill wall and install watertight entrance seal device.
6. Nonwaterproofed Wall or Floor (Underground, without Concrete Encasement):
 - a. Provide Schedule 40 galvanized pipe sleeve, or watertight entrance seal device.
 - b. Fill space between raceway and sleeve with expandable plastic compound or oakum and lead joint, on each side.

3.05 SUPPORT

- A. Support from structural members only, at intervals not exceeding NFPA 70 requirements. Do not exceed 10 feet in any application. Do not support from piping, pipe supports, or other raceways.
- B. Multiple Adjacent Raceways: Provide ceiling trapeze. For trapeze-supported conduit, allow 25 percent extra space for future conduit.
- C. Application/Type of Conduit Strap:
 1. Aluminum Conduit: Aluminum or stainless steel.
 2. Rigid Steel Conduit: Zinc coated steel, pregalvanized steel or malleable iron.
 3. PVC-Coated Rigid Steel Conduit: PVC-coated metal.
 4. Nonmetallic Conduit: Nonmetallic or PVC-coated metal.
- D. Provide and attach wall brackets, strap hangers, or ceiling trapeze as follows:
 1. Wood: Wood screws.
 2. Hollow Masonry Units: Toggle bolts.
 3. Concrete or Brick: Expansion shields, or threaded studs driven in by powder charge, with lock washers and nuts.
 4. Steelwork: Machine screws.
 5. Location/Type of Hardware:
 - a. Dry, Noncorrosive Areas: Galvanized.
 - b. Wet, Noncorrosive Areas: Stainless steel.
 - c. Corrosive Areas: Stainless steel.
- E. Nails or wooden plugs inserted in concrete or masonry for attaching raceway not permitted. Do not weld raceways or pipe straps to steel structures. Do not use wire in lieu of straps or hangers.
- F. Support aluminum conduit on concrete surfaces with stainless steel or nonmetallic spacers, or aluminum or nonmetallic framing channel.

3.06 BENDS

- A. Install concealed raceways with a minimum of bends in the shortest practical distance.
- B. Make bends and offsets of longest practical radius. Bends in conduits and ducts being installed for fiber optic cables shall be not less than 20 times cable diameter, 15 inches minimum.
- C. Install with symmetrical bends or cast metal fittings.
- D. Avoid field-made bends and offsets, but where necessary, make with acceptable hickey or bending machine. Do not heat metal raceways to facilitate bending.
- E. Make bends in parallel or banked runs from same center or centerline with same radius so that bends are parallel.
- F. Factory elbows may be installed in parallel or banked raceways if there is change in plane of run, and raceways are same size.
- G. Flexible Conduit: Do not make bends that exceed allowable conductor bending radius of cable to be installed or that significantly restricts conduit flexibility.

3.07 EXPANSION/DEFLECTION FITTINGS

- A. Provide on raceways at structural expansion joints and in long tangential runs.
- B. Provide expansion/deflection joints for 25 degrees C maximum temperature variation.
- C. Install in accordance with manufacturer's instructions.

3.08 PVC-COATED RIGID STEEL AND RIGID ALUMINUM CONDUIT

- A. Install in accordance with manufacturer's instructions.
- B. Tools and equipment used in cutting, bending, threading and installation of PVC-coated rigid conduit shall be designed to limit damage to PVC coating.
- C. Provide PVC boot to cover exposed threading.

3.09 WIREWAYS

- A. Install in accordance with manufacturer's instructions.
- B. Locate with cover on accessible vertical face of wireway, unless otherwise shown.

C. Applications:

1. Metal wireway in indoor dry locations.
2. Nonmetallic wireway in indoor wet, outdoor, and corrosive locations.

3.10 TERMINATION AT ENCLOSURES

A. Cast Metal Enclosure: Install manufacturer's premolded insulating sleeve inside metallic conduit terminating in threaded hubs.

B. Nonmetallic, Cabinets, and Enclosures:

1. Terminate conduit in threaded conduit hubs, maintaining enclosure integrity.
2. Metallic Conduit: Provide ground terminal for connection to maintain continuity of ground system.

C. Sheet Metal Boxes, Cabinets, and Enclosures:

1. General:

- a. Install insulated bushing on ends of conduit where grounding is not required.
- b. Provide insulated throat when conduit terminates in sheet metal boxes having threaded hubs.
- c. Utilize sealing locknuts or threaded hubs on sides and bottom of NEMA 3R and NEMA 12 enclosures.
- d. Terminate conduits at threaded hubs at the tops of NEMA 3R and NEMA 12 boxes and enclosures.
- e. Terminate conduits at threaded conduit hubs at NEMA 4 and NEMA 4X boxes and enclosures.

2. Rigid Galvanized or Aluminum Conduit:

- a. Provide one lock nut each on inside and outside of enclosure.
- b. Install grounding bushing at source enclosure.
- c. Provide bonding jumper from grounding bushing to equipment ground bus or ground pad.

3. Electric Metallic Tubing: Provide gland compression, insulated connectors.

4. Flexible Metal Conduit: Provide two screw type, insulated, malleable iron connectors.

5. Flexible, Nonmetallic Conduit: Provide nonmetallic, liquid-tight strain relief connectors.

6. PVC-Coated Rigid Galvanized Steel Conduit: Provide PVC-coated, liquid-tight, metallic connector.

- D. Motor Control Center, Switchgear, and Free-Standing Enclosures:
 - 1. Terminate metal conduit entering bottom with grounding bushing; provide grounding jumper extending to equipment ground bus or grounding pad.
 - 2. Terminate PVC conduit entering bottom with bell end fittings.

3.11 OUTLET AND DEVICE BOXES

A. General:

- 1. Install plumb and level.
- 2. Install suitable for conditions encountered at each outlet or device in wiring or raceway system, sized to meet NFPA 70 requirements.
- 3. Open no more knockouts in sheet steel device boxes than are required, seal unused openings.
- 4. Install galvanized mounting hardware in industrial areas.

B. Size:

- 1. Depth: Minimum 2 inches, unless otherwise required by structural conditions. Box extensions not permitted.
 - a. Hollow Masonry Construction: Install with sufficient depth such that conduit knockouts or hubs are in masonry void space.
- 2. Ceiling Outlet: Minimum 4-inch octagonal device box, unless otherwise required for installed fixture.
- 3. Switch and Receptacle: Minimum 2-inch by 4-inch device box.

C. Locations:

- 1. Drawing locations are approximate.
- 2. To avoid interference with mechanical equipment or structural features, relocate outlets as directed by Engineer.
- 3. Light Fixture: Install in symmetrical pattern according to room layout, unless otherwise shown.

D. Mounting Height:

- 1. General:
 - a. Dimensions given to centerline of box.
 - b. Where specified heights do not suit building construction or finish, adjust up or down to avoid interference.
 - c. Do not straddle CMU block or other construction joints.
- 2. Light Switch:
 - a. 48 inches above floor.
 - b. When located next to door, install on lock side of door.
- 3. Thermostat: 54 inches above floor.

4. Telephone Outlet:
 - a. 15 inches above floor.
 - b. 6 inches above counter tops.
 - c. Wall Mounted: 52 inches above floor.
 5. Convenience Receptacle:
 - a. General Interior Areas: 15 inches above floor.
 - b. General Interior Areas (Counter Tops): Install device plate bottom or side flush with top of backsplash, or 6 inches above counter tops without backsplash.
 - c. Industrial Areas, Workshops: 48 inches above floor.
 - d. Outdoor Areas: 24 inches above finished grade.
 6. Switch, Motor Starting: 48 inches above floor, unless otherwise indicated on Drawings.
- E. Flush Mounted:
1. Install with concealed conduit.
 2. Install proper type extension rings or plaster covers to make edges of boxes flush with finished surface.
 3. Holes in surrounding surface shall be no larger than required to receive box.
- F. Supports:
1. Support boxes independently of conduit by attachment to building structure or structural member.
 2. Install bar hangers in frame construction or fasten boxes directly as follows:
 - a. Wood: Wood screws.
 - b. Concrete or Brick: Bolts and expansion shields.
 - c. Hollow Masonry Units: Toggle bolts.
 - d. Steelwork: Machine screws.
 3. Threaded studs driven in by powder charge and provided with lock washers and nuts are acceptable in lieu of expansion shields.
 4. Provide plaster rings where necessary.
 5. Boxes embedded in concrete or masonry need not be additionally supported.
- G. Install separate junction boxes for flush or recessed lighting fixtures where required by fixture terminal temperature.
- H. Boxes Supporting Fixtures: Provide means of attachment with adequate strength to support fixture.

3.12 JUNCTION AND PULL BOXES

A. General:

1. Install plumb and level.
2. Installed boxes shall be accessible.
3. Do not install on finished surfaces.
4. Use outlet boxes as junction and pull boxes wherever possible and allowed by applicable codes.
5. Use conduit bodies as junction and pull boxes where no splices are required and allowed by applicable codes.
6. Install pull boxes where necessary in raceway system to facilitate conductor installation.
7. Install where shown and where necessary to terminate, tap-off, or redirect multiple conduit runs.
8. Install in conduit runs at least every 150 feet or after the equivalent of three right-angle bends.

B. Flush Mounted:

1. Install with concealed conduit.
2. Holes in surrounding surface shall be no larger than required to receive box.
3. Make edges of boxes flush with final surface.

C. Mounting Hardware:

1. Noncorrosive Dry Areas: Galvanized.
2. Noncorrosive Wet Areas: Stainless steel.
3. Corrosive Areas: Stainless steel.

D. Supports:

1. Support boxes independently of conduit by attachment to building structure or structural member.
2. Install bar hangers in frame construction or fasten boxes directly as follows:
 - a. Wood: Wood screws.
 - b. Concrete or Brick: Bolts and expansion shields.
 - c. Hollow Masonry Units: Toggle bolts.
 - d. Steelwork: Machine screws.
3. Threaded studs driven in by powder charge and provided with lock washers and nuts are acceptable in lieu of expansion shields.
4. Boxes embedded in concrete or masonry need not be additionally supported.

- E. At or Below Grade:
 - 1. Install boxes for below grade conduit flush with finished grade in locations outside of paved areas, roadways, or walkways.
 - 2. If adjacent structure is available, box may be mounted on structure surface just above finished grade in accessible but unobtrusive location.
 - 3. Obtain Engineer's written acceptance prior to installation in paved areas, roadways, or walkways.
 - 4. Use boxes and covers suitable to support anticipated weights.
- F. Install Drain/breather fittings in NEMA 250 Type 4 and Type 4X enclosures.

3.13 EMPTY RACEWAYS

- A. Provide permanent, removable cap over each end.
- B. Provide PVC plug with pull tab for underground raceways with end bells.
- C. Provide nylon pull cord.
- D. Identify, as specified in Article Identification Devices, with waterproof tags attached to pull cord at each end, and at intermediate pull point.

3.14 IDENTIFICATION DEVICES

- A. Raceway Tags:
 - 1. Identify origin and destination.
 - 2. For exposed raceways, install tags at each terminus, near midpoint, and at minimum intervals of every 50 feet, whether in ceiling space or surface mounted.
 - 3. Install tags at each terminus for concealed raceways.
 - 4. Provide nylon strap for attachment.

3.15 PROTECTION OF INSTALLED WORK

- A. Protect products from effects of moisture, corrosion, and physical damage during construction.
- B. Provide and maintain manufactured watertight and dust-tight seals over conduit openings during construction.
- C. Touch up painted conduit threads after assembly to cover nicks or scars.
- D. Touch up coating damage to PVC-coated conduit with patching compound approved by manufacturer. Compound shall be kept refrigerated according to manufacturers' instructions until time of use.

END OF SECTION

SECTION 40 05 15
PIPING SUPPORT SYSTEMS

PART 1 GENERAL

1.01 REFERENCES

- A. The following is a list of standards which may be referenced in this section:
1. American Society of Civil Engineers (ASCE): 7, Minimum Design Loads for Buildings and Other Structures.
 2. American Society of Mechanical Engineers (ASME): B31.1, Power Piping.
 3. ASTM International (ASTM):
 - a. A123/A123M, Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
 - b. A653/A653M, Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvanealed) by the Hot-Dip Process.
 - c. E84, Standard Test Method for Surface Burning Characteristics of Building Materials.
 4. International Code Council (ICC):
 5. International Building Code (IBC).
 6. International Mechanical Code (IMC).
 7. Manufacturers' Standardization Society (MSS):
 - a. SP-58, Pipe Hangers and Supports—Materials, Design and Manufacture.

1.02 DEFINITIONS

- A. FRP: Glass fiber-reinforced plastic.
- B. Containment Area: Area within chemical containment, up to the top elevation of the containment walls.

1.03 SUBMITTALS

- A. Provide submittals in accordance with the General Conditions and Section 01 33 00, Submittal Procedures.
- B. Action Submittals:
1. Shop Drawings
 - a. Submit shop drawings for all hangers, braces, supports and expansion joints required for a complete support system for each piping system including location, installation, material, loads or forces, and deflection of all hangers, braces and supports.

- b. Submit calculations and complete engineering analysis for each pipe system for all loads, forces and deflections on the hangers and supports and their reaction forces transmitted to the structure to which they are attached. Comply with MSS SP 58 and MSS SP 69 for load ratings, materials, and installation.
 - 1) Show all anticipated locations, amounts and directions of pipe movements or deflections under working or test pressures and temperatures.
 - 2) Show locations and design details of all supports, braces, guides, etc., necessary to control movement and deflection and maintain straight and plumb piping alignment.
 - 3) Provide complete engineering analysis of supports for all piping systems using grooved or shouldered couplings specified.
 - 4) Analyze expansion and contraction and design rigid and sliding pipe supports and expansion joints as required.
2. Provide drawings as follows:
 - a. Plans of all piping layouts at a scale of 1/4 inch equal to 1 foot, showing the location of each pipe hanger, support or brace. Provide details or cut sheets of each item, and provide a reference or key system.
 - b. Show, in section view, clearances beneath and around all pipes supported on beams, trapeze-type hangers, posts, etc. Verify that hanger or support location does not compromise clear and safe walking or working areas.
3. Product Data: Submit manufacturers' catalogs, literature, and engineering data on all hangers, supports and expansion joints. Load ratings, materials and installation shall be consistent with the recommendations of MSS SP 58 and MSS SP 69.
4. Design Calculations:
 - a. Supports and Hangers for Horizontal Pipe: Provide a table of each size and type line to be supported and list support spacing, which will be used. Reference spacing shown to MSS SP 69 and, where MSS SP 69 does not apply, provide additional specific load and beam calculations for pipelines.
 - b. Braces (kickers and rigid supports): Provide thrust and surge calculations to show design loads, and structural calculations to show brace resisting capabilities.
 - c. Expansion and construction calculations and expansion joint design.
5. Design Certification: All pipe system analysis, design calculations, and support/anchor drawings shall be stamped by a licensed professional engineer registered in the State of Virginia.

1.04 DESIGN REQUIREMENTS

A. System Description:

1. Design, size, and locate piping support systems throughout facility, whether shown or not.
2. Design, size, and locate support systems for valves and valve actuators throughout facility, as necessary, whether shown or not.
3. Supports are shown only where specific types and locations are required; additional pipe supports may be required.
4. Meet requirements of MSS SP-58 and ASME B31.1 or as modified by this section.

B. Pipe Support Systems:

1. Design pipe support systems for gravity and thrust loads imposed by weight of pipes or internal pressures, including but not limited to, valves, valve actuators, and weight of fluid in pipes.
2. Design loading of hangers and supports for chemical truck unload piping shall include forces caused by air unloading, if applicable.
3. Supports shall be designed such that no appreciable pipe sway is present under load. Sway bracing or other structural support members shall be integrated into the support system to prevent sway.
4. Maximum Support Spacing and Minimum Rod Size: In accordance MSS SP-58 Table 3 and Table 4.
5. Electrical Conduit Support: Include in design of framing support system.

C. Anchoring Devices: Design, size, and space support anchoring devices, including anchor bolts, inserts, and other devices used to anchor support, to withstand shear and pullout loads imposed by loading and spacing on each particular support.

D. Vertical Sway Bracing: 10-foot maximum centers or as shown.

E. Existing Support Systems: Use existing supports systems to support new piping only if Contractor can show they are adequate for additional load, or if they are strengthened to support additional load.

F. General Design Criteria:

1. Provide hangers and supports that are adjustable.
2. Provide hangers, supports, braces and appurtenances, which will permit the disassembly of both the support and the piping system. In general, bolted friction or clamp type devices shall be used, and totally welded hangers and supports, or hangers and supports which are welded to the pipe, will not be acceptable.

3. Provide hangers and supports, which will not obstruct, or create safety hazards within, normal walkways or traffic patterns.
4. Provide hangers, supports, and appurtenances in locations that will not obstruct routine access to or operation of adjacent valves, equipment, or components.
5. Design loading of hangers and supports shall be based on the total weight of pipe, fittings, valves, accessories, insulation, and contents of the pipe supported and shall include forces caused by expansion, contraction, and thrust due to pressure and temperature changes and all appropriate flow considerations.
6. Supports and hangers shall be sized to carry the calculated design loading, including vibrations, in accordance with MSS SP-58.
7. Supports shall be designed such that no appreciable pipe sway is present under load. Sway bracing or other structural support members shall be integrated into the support system to prevent sway.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Pipe supports and hardware shall be as manufactured by:
 1. Anvil International, Inc.
 2. Cooper B-Line.
 3. Enduro.
 4. Century Composite.
 5. "Or-equal."
- B. Channel type pipe support systems and accessories shall accessories shall be as manufactured by:
 1. Cooper B-Line.
 2. Unistrut.
 3. Anvil International, Inc.
 4. Aickinstrut.
 5. "Or-equal."

2.02 MATERIALS

- A. Materials of construction for pipe supports, including hangers, brackets, hardware and related items shall be as specified herein.
- B. PVC or CPVC Pipe: Supports and hardware shall be primarily FRP as described herein.

2.03 MANUFACTURED UNITS

- A. Pipe Attachments: The following types of pipe attachments are acceptable for those types of piping systems shown on the Drawings:
1. Adjustable Steel Clevis: MSS SP-58, Type 1.
 2. Steel Three Bolt Pipe Clamp: MSS SP-58, Type 3.
 3. Steel Pipe Clamp: MSS SP-58, Type 4.
 4. Adjustable Swivel Pipe Ring: MSS SP-58, Type 6.
 5. Adjustable Steel Band Hanger: MSS SP-58, Type 7.
 6. Riser Clamp: MSS SP-58, Type 8.
 7. Long Clips: MSS SP-58, Type 26.
 8. Welded Steel Wall Bracket: MSS SP-58, Type 33 (heavy-duty).
 9. Steel Pipe Covering Protection Saddle: MSS SP-58, Type 39.
 10. Insulation Protection Shield: MSS SP-58, Type 40.
 11. Pipe Saddle Support: MSS SP-58, Type 36.
 12. Pipe Stanchion Saddle: MSS SP-58, Type 37.
 13. Adjustable Roller Hanger/Roller Chair: MSS SP-58, Type 43.
 14. Single Pipe Roll Support Hanger: MSS SP-58, Type 41.
 15. Pipe Support Bolted to Flange: Standon Model S89.
 16. Alignment Guides: Spider with 4 guiding fingers and guiding cylinder with base.
- B. Structural Attachments: The following types of structural attachments are acceptable.
1. I-Beam Clamp: Concentric Loading Type, MSS SP-58, Type 21, Type 28, Type 29 or Type 30, which engage both sides of flange.
 2. Welded Steel Bracket: MSS SP-58, Types 31 and 32.
 3. Malleable Concrete Insert: MSS-SP-58, Type 18.
- C. Hanger Rod Attachments: Use as required to complete assembly.
1. Forged Steel Cleaves: MSS SP-58, Type 14.
 2. Adjustable Turnbuckle: MSS SP-58, Type 15.
 3. Forged Steel Weldless Eye Nut: MSS SP-58, Type 17.
- D. Sodium Hypochlorite Pipe and Other Pipe Within Sodium Hypochlorite Containment Areas.
1. All pipe supports shall be glass FRP with a flame spread rating of 25, in accordance with ASTM E84. Grade 2 Titanium is also acceptable.
 2. FRP materials shall be manufactured by either the pultrusion or extrusion process, as applicable.
 3. All FRP pipe supports shall have a surface veil over 100 percent of the surface which, along with a filler system, shall protect against degradation from ultra-violet light.

4. All fasteners and all-thread rods shall be manufactured from long glass fiber-reinforced vinyl ester to ensure strength and corrosion resistance. Grade 2 Titanium is also an acceptable fastener material.
5. These requirements shall also apply to non-sodium hypochlorite service thermoplastic piping located within sodium hypochlorite containment areas.

2.04 COMPONENTS

- A. Brackets: Brackets for wall mounting shall conform to MSS SP-58.
- B. Channel Type Pipe Support: 1-5/8 inches by 1-5/8 inches by 12 gage minimum size. FRP channel supports shall be 1-1/2 inches wide, minimum. Provide fittings as required for securing pipe attachments. Clamps, rollers, and supports for piping shall conform to the general requirements of MSS SP 69.

2.05 ACCESSORIES

- A. Anchor Bolts:
 1. Size and Material: Sized by Contractor for required loads, 1/2-inch minimum diameter, and as specified in Section 05 50 00, Metal Fabrications.
 2. Bolt Length (Extension Above Top of Nut):
 - a. Minimum Length: Flush with top of nut preferred. If not flush, shall be no more than one thread recessed below top of nut.
 - b. Maximum Length: No more than a full nut depth above top of nut.
- B. Insulation Shields:
 1. Type: Galvanized steel or stainless steel, MSS SP-58, Type 40.
 2. Manufacturers and Products:
 - a. Anvil; Figure 167, sizes 1/2 inch through 24 inches.
 - b. B-Line; Figure B3151, sizes 1/2 inch through 24 inches.
- C. Plastic Pipe Support Channel:
 1. Type: Continuous support for plastic pipe and to increase support spacing.
 2. Manufacturer and Product: B-Line; Figure Series B3106V, sizes 1/2 inch through 6 inches with Figure B3106 Vee bottom hanger.
- D. Hanger Rods, Clevises, Nuts, Sockets, and Turnbuckles: In accordance with MSS SP 58.

E. Attachments:

1. I-Beam Clamp: Concentric loading type, MSS SP 58, Type 21, Type 28, Type 29, or Type 30, which engage both sides of flange.
2. Concrete Insert: MSS SP 58, Type 18, continuous channel insert with load rating not less than that of hanger rod it supports.
3. Welded Beam Attachment: MSS SP 58, Type 22.
 - a. Anvil; Figure 66.
 - b. B-Line; Figure B3083.
4. U-Channel Concrete Inserts: As specified in Section 05 50 00, Metal Fabrications.
5. Concrete Attachment Plates:
 - a. Anvil; Figure 47, Figure 49, or Figure 52.
 - b. B-Line; Figure B3084, Figure B3085, or Figure B3086.

PART 3 EXECUTION

3.01 INSTALLATION

A. General:

1. Install support systems in accordance with MSS SP 58, unless shown otherwise.
2. Install pipe hanger rods plumb, within 4 degrees of vertical during shut down, start up or operations.
3. Support piping connections to equipment by pipe support and not by equipment.
4. Support large or heavy valves, fittings, and appurtenances independently of connected piping.
5. Support no pipe from pipe above it.
6. Support pipe at changes in direction or in elevation, adjacent to flexible joints and couplings, and where shown.
7. Do not use adhesive anchors for attachment of supports to ceiling or walls.
8. Do not install pipe supports and hangers in equipment access areas or bridge crane runs.
9. Brace hanging pipes against horizontal movement by both longitudinal and lateral sway bracing and to reduce movement after startup.
10. Install lateral supports for seismic loads at changes in direction.
11. Install pipe anchors where required to withstand expansion thrust loads and to direct and control thermal expansion.
12. Repair mounting surfaces to original condition after attachments are completed.

B. Standard Pipe Supports:

1. Horizontal Suspended Piping:
 - a. Single Pipes: Clevis hangers or adjustable swivel split-ring.
 - b. Grouped Pipes: Trapeze hanger system.
2. Horizontal Piping Supported from Walls:
 - a. Single Pipes: Wall brackets, or attached to wall, or to wall mounted framing with anchors.
 - b. Stacked Piping: Wall mounted framing system and “J” hangers acceptable for pipe smaller than 3-inch.
 - c. Pipe clamp that resists axial movement of pipe through support is not acceptable. Use pipe rollers supported from wall bracket.
3. Horizontal Piping Supported from Floors:
 - a. Saddle Supports:
 - 1) Pedestal Type, elbow and flange.
 - 2) Provide minimum 1-1/2-inch grout beneath baseplate.
 - b. Floor Mounted Channel Supports:
 - 1) Use for pipe smaller than 3-inch running along floors and in trenches at pipe elevations lower than can be accommodated using pedestal pipe supports.
 - 2) Attach channel framing to floors with baseplate on minimum 1-1/2-inch nonshrink grout and with anchor bolts.
 - 3) Attach pipe to channel with clips or pipe clamps.
 - c. Concrete Cradles: Use for pipe larger than 3 inches along floor and in trenches at pipe elevations lower than can be accommodated using stanchion type.
4. Insulated Pipe:
 - a. Pipe hanger and support shall be on outside of insulation. Do not enclose within insulation.
 - b. Provide precut 120-degree sections of rigid insulation (minimum length same as shield), shields and oversized hangers or insulated saddle system (ISS).
 - c. Wall-mounted pipe clips not acceptable for insulated piping.
5. Vertical Pipe: Support with wall bracket and elbow support, or riser clamp on floor penetration.

C. Standard Attachments:

1. New Concrete Ceilings: Concrete inserts, concrete attachment plates, or concrete anchors as limited below:
 - a. Single point attachment to ceiling allowed only for 3/4-inch rod and smaller (8 inches and smaller pipe).
2. Existing Concrete Ceilings: Channel type support with minimum of two anchor points, concrete attachment plates or concrete anchors as limited below:
 - a. Single point attachment to ceiling is allowed only for 3/4-inch rod and smaller (8 inches and smaller pipe).

3. Steel Beams: I-beam clamp or welded attachments.
4. Concrete Walls: Concrete inserts or brackets or clip angles with concrete anchors.
5. Concrete Beams: Concrete inserts, or if inserts are not used attach to vertical surface similar to concrete wall. Do not drill into beam bottom.

D. Intermediate and Pipe Alignment Guides:

1. Provide pipe alignment guides, or pipe supports that provide same function, at expansion joints and loops.
2. Guide pipe on each side of expansion joint or loop at 4 pipe and 14 pipe diameters from each joint or loop.
3. Install intermediate guides on metal framing support systems not carrying pipe anchor or alignment guide.

E. Accessories:

1. Insulation Shield: Install on insulated piping with oversize rollers and supports.

3.02 FIELD FINISHING

- A. Paint components to match existing conditions.

3.03 SUPPLEMENTS

- A. The supplements listed below, following “End of Section,” are a part of this specification:

1. Table 1: Nonchemical Areas.
2. Table 2: Chemical Areas.

END OF SECTION

Table 1
Nonchemical Areas

| Exposure Conditions | Support Material |
|---|---|
| Process Areas: High Humidity or Outdoors | Stainless steel or FRP |
| Process Areas: Wetted or Submerged | Stainless steel or FRP |
| Pipes conveying chemicals listed in Table 2 | Provide with corresponding support per Table 2. |
| Notes: 1. Stainless steel to be Type 304 or 316. | |

| Table 2 | |
|--|--------------------------------------|
| Chemical Areas | |
| Exposure Conditions | Support Material |
| Sodium Hypochlorite | FRP, Hastelloy C or Grade 2 Titanium |
| Notes: | |
| 1. Sodium hypochlorite exposure areas includes entire NFF and SHF buildings (except electrical rooms). | |

SECTION 40 27 00
PROCESS PIPING—GENERAL

PART 1 GENERAL

1.01 REFERENCES

- A. The following is a list of standards which may be referenced in this section and any supplemental Data Sheets:
1. American Society of Mechanical Engineers (ASME):
 - a. B16.21, Nonmetallic Flat Gaskets for Pipe Flanges.
 - b. B31.3, Process Piping.
 - c. B31.9, Building Services Piping.
 2. American Water Works Association (AWWA):
 - a. C104/A21.4, Cement-Mortar Lining for Ductile-Iron Pipe and Fittings.
 - b. C105/A21.5, Polyethylene Encasement for Ductile-Iron Pipe Systems.
 - c. C110/A21.10, Ductile-Iron and Gray-Iron Fittings.
 - d. C111/A21.11, Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings.
 - e. C115/A21.15, Flanged Ductile-Iron Pipe with Ductile-Iron or Gray-Iron Threaded Flanges.
 - f. C151/A21.51, Ductile-Iron Pipe, Centrifugally Cast.
 - g. C153/A21.53, Ductile-Iron Compact Fittings.
 - h. C207, Steel Pipe Flanges for Waterworks Service, Sizes 4 In. Through 144 In. (100 mm Through 3,600 mm).
 - i. C606, Grooved and Shouldered Joints.
 3. American Welding Society (AWS):
 - a. QC1, Standard for AWS Certification of Welding Inspectors.
 4. ASTM International (ASTM):
 - a. A126, Standard Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings.
 - b. A194/A194M, Standard Specification for Carbon and Alloy Steel Nuts for Bolts for High Pressure or High Temperature Service, or Both.
 - c. A395/A395M, Standard Specification for Ferritic Ductile Iron Pressure-Retaining Castings for Use at Elevated Temperatures.
 - d. A403/A403M, Standard Specification for Wrought Austenitic Stainless Steel Piping Fittings.
 - e. A409/A409M, Standard Specification for Welded Large Diameter Austenitic Steel Pipe for Corrosive or High-Temperature Service.
 - f. A536, Standard Specification for Ductile Iron Castings.
 - g. A563, Standard Specification for Carbon and Alloy Steel Nuts.

- h. A587, Standard Specification for Electric-Resistance-Welded Low-Carbon Steel Pipe for the Chemical Industry.
- i. A743/A743M, Standard Specification for Castings, Iron-Chromium, Iron-Chromium-Nickel, Corrosion Resistant, for General Application.
- j. A744/A744M, Standard Specification for Castings, Iron-Chromium-Nickel, Corrosion Resistant, for Severe Service.
- k. A774/A774M, Standard Specification for As-Welded Wrought Austenitic Stainless Steel Fittings for General Corrosive Service at Low and Moderate Temperatures.
- l. C582, Standard Specification for Contact-Molded Reinforced Thermosetting Plastic (RTP) Laminates for Corrosion-Resistant Equipment.
- m. D412, Standard Test Methods for Vulcanized Rubber and Thermoplastic Elastomers-Tension.
- n. D413, Standard Test Methods for Rubber Property-Adhesion to Flexible Substrate.
- o. D543, Standard Practices for Evaluating the Resistance of Plastics to Chemical Reagents.
- p. D1248, Standard Specification for Polyethylene Plastics Extrusion Materials for Wire and Cable.
- q. D1330, Standard Specification for Rubber Sheet Gaskets.
- r. D1784, Standard Specification for Rigid Poly(Vinyl Chloride) (PVC) Compounds and Chlorinated Poly(Vinyl Chloride) (CPVC) Compounds.
- s. D1785, Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, and 120.
- t. D2000, Standard Classification System for Rubber Products in Automotive Applications.
- u. D2310, Standard Classification for Machine-Made “Fiberglass” (Glass-Fiber-Reinforced Thermosetting-Resin) Pipe.
- v. D2464, Standard Specification for Threaded Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 80.
- w. D2466, Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 40.
- x. D2467, Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 80.
- y. D2564, Standard Specification for Solvent Cements for Poly(Vinyl Chloride) (PVC) Plastic Piping Systems.
- z. D2837, Standard Test Method for Obtaining Hydrostatic Design Basis for Thermoplastic Pipe Materials or Pressure Design Basis for Thermoplastic Pipe Products.
- aa. D2996, Standard Specification for Filament-Wound “Fiberglass” (Glass-Fiber-Reinforced Thermosetting-Resin) Pipe.
- bb. D3222, Standard Specification for Unmodified Poly(Vinylidene Fluoride) (PVDF) Molding Extrusion and Coating Materials.

- cc. D3350, Standard Specification for Polyethylene Plastics Pipe and Fittings Materials.
- dd. D4101, Standard Specification for Polypropylene Injection and Extrusion Materials.
- ee. F436, Standard Specification for Hardened Steel Washers.
- ff. F437, Standard Specification for Threaded Chlorinated Poly(Vinyl Chloride) (CPVC) Plastic Pipe Fittings, Schedule 80.
- gg. F439, Standard Specification for Chlorinated Poly(Vinyl Chloride) (CPVC) Plastic Pipe Fittings, Schedule 80.
- hh. F441/F441M, Standard Specification for Chlorinated Poly(Vinyl Chloride) (CPVC) Plastic Pipe, Schedules 40 and 80.
- ii. F493, Standard Specification for Solvent Cements for Chlorinated Poly(Vinyl Chloride) (CPVC) Plastic Pipe and Fittings.
- jj. F593, Standard Specification for Stainless Steel Bolts, Hex Cap Screws, and Studs.
- kk. F656, Standard Specification for Primers for Use in Solvent Cement Joints of Poly(Vinyl Chloride) (PVC) Plastic Pipe and Fittings.

1.02 DESIGN REQUIREMENTS

- A. Where pipe diameter, thickness, pressure class, pressure rating, or thrust restraint is not shown or specified, design piping system in accordance with the following:
 - 1. Process Piping: ASME B31.3, normal fluid service unless otherwise specified.

1.03 SUBMITTALS

- A. Action Submittals:
 - 1. Shop Fabricated Piping:
 - a. Detailed pipe fabrication or spool drawings showing special fittings and bends, dimensions, coatings, and other pertinent information.
 - b. Layout drawing showing location of each pipe section and each special length; number or otherwise designate laying sequence on each piece.
 - 2. Pipe Wall Thickness: Identify wall thickness and rational method or standard applied to determine wall thickness for each size of each different service including exposed, submerged, buried, and concrete-encased installations for Contractor-designed piping.
 - 3. Hydraulic Thrust Restraint for Restrained Joints: Details including materials, sizes, assembly ratings, and pipe attachment methods.
 - 4. Pipe Corrosion Protection: Product data.

B. Informational Submittals:

1. Flanged Pipe and Fittings: Manufacturer's product data sheets for gaskets including torquing requirements and bolt tightening procedures.

1.04 DELIVERY, STORAGE, AND HANDLING

A. In accordance with Section 01 61 00, Common Product Requirements, and:

1. Flanges: Securely attach metal, hardboard, or wood protectors over entire gasket surface.
2. Threaded or Socket Welding Ends: Fit with metal, wood, or plastic plugs or caps.
3. Linings and Coatings: Prevent excessive drying.
4. Cold Weather Storage: Locate products to prevent coating from freezing to ground.
5. Handling: Use heavy canvas or nylon slings to lift pipe and fittings.

PART 2 PRODUCTS

2.01 PIPING

- A. As specified on Piping Data Sheet(s) and Piping Schedule located at the end of this section as Supplement.
- B. Diameters Shown:
1. Standardized Products: Nominal size.
 2. Fabricated Steel Piping (Except Cement-Lined): Outside diameter, ASME B36.10M.
 3. Cement-Lined Steel Pipe: Lining inside diameter.

2.02 JOINTS

- A. As specified on Piping Data Sheet(s) and Piping Schedule located at the end of this section as Supplement.
- B. Flanged Joints:
1. Flat-faced, carbon steel, or alloy flanges when mating with flat-faced cast or ductile iron flanges.
 2. Higher pressure rated flanges as required to mate with equipment when equipment flange is of higher pressure rating than required for piping.
- C. Threaded Joints: NPT taper pipe threads in accordance with ASME B1.20.1.

2.03 GASKET LUBRICANT

- A. Lubricant shall be supplied by pipe manufacturer and no substitute or “or-equal” will be allowed.

2.04 FABRICATION

- A. Mark each pipe length on outside with the following:
 - 1. Size or diameter and class.
 - 2. Manufacturer’s identification and pipe serial number.
 - 3. Location number on laying drawing.
 - 4. Date of manufacture.
- B. Code markings according to approved Shop Drawings.
- C. Shop fabricate flanged pipe in shop, not in field, and delivered to Site with flanges in place and properly faced. Threaded flanges shall be individually fitted and machine tightened on matching threaded pipe by manufacturer.

2.05 FINISHES

- A. Factory prepare, prime, and finish coat in accordance with Pipe Data Sheet(s) and Piping Schedule.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Verify size, material, joint types, elevation, horizontal location, and pipe service of existing pipelines to be connected to new pipelines or new equipment.
- B. Inspect size and location of structure penetrations to verify adequacy of wall pipes, sleeves, and other openings.

3.02 PREPARATION

- A. See Piping Schedule for additional requirements.
- B. Notify Engineer at least two weeks prior to field fabrication of pipe or fittings.
- C. Inspect pipe and fittings before installation, clean ends thoroughly, and remove foreign matter and dirt from inside.
- D. Damaged Coatings and Linings: Repair using original coating and lining materials in accordance with manufacturer’s instructions.

3.03 INSTALLATION—GENERAL

- A. Join pipe and fittings in accordance with manufacturer's instructions, unless otherwise shown or specified.
- B. Remove foreign objects prior to assembly and installation.
- C. Flanged Joints:
 - 1. Install perpendicular to pipe centerline.
 - 2. Bolt Holes: Straddle vertical centerlines, aligned with connecting equipment flanges or as shown.
 - 3. Use torque-limiting wrenches to ensure uniform bearing and proper bolt tightness.
 - 4. Plastic Flanges: Install annular ring filler gasket at joints of raised-face flange.
 - 5. Flange fillers are to be avoided, but if necessary, may be used to make up for small angles up to 6 degrees and for filling gaps up to 2 inches between flanges. Stacked flange fillers shall not be used.
 - 6. Threaded flanged joints shall be shop fabricated and delivered to Site with flanges in-place and properly faced.
 - 7. Manufacturer: Same as pipe.
- D. Threaded and Coupled Joints:
 - 1. Conform to ASME B1.20.1.
 - 2. Produce sufficient thread length to ensure full engagement when screwed home in fittings.
 - 3. Countersink pipe ends, ream and clean chips and burrs after threading.
 - 4. Make connections with not more than three threads exposed.
 - 5. Lubricate male threads only with thread lubricant or tape as specified on Piping Data Sheets.
- E. PVC and CPVC Piping:
 - 1. Use strap wrench for tightening threaded plastic joints. Do not overtighten fittings.
 - 2. Do not thread or use Schedule 40 pipe.

3.04 INSTALLATION—EXPOSED PIPING

- A. Piping Runs:
 - 1. Parallel to building or column lines and perpendicular to floor, unless shown otherwise.
 - 2. Piping upstream and downstream of flow measuring devices shall provide straight lengths as required for accurate flow measurement.

- B. Supports: As specified in Section 40 05 15, Piping Support Systems.
- C. Group piping wherever practical at common elevations; install to conserve building space and not interfere with use of space and other work.
- D. Unions or Flanges: Provide at each piping connection to equipment or instrumentation on equipment side of each block valve to facilitate installation and removal.
- E. Install piping so that no load or movement in excess of that stipulated by equipment manufacturer will be imposed upon equipment connection; install to allow for contraction and expansion without stressing pipe, joints, or connected equipment.
- F. Piping clearance, unless otherwise shown:
 - 1. Over Walkway and Stairs: Minimum of 7 feet 6 inches, measured from walking surface or stair tread to lowest extremity of piping system including flanges, valve bodies or mechanisms, insulation, or hanger/support systems.
 - 2. Between Equipment or Equipment Piping and Adjacent Piping: Minimum 3 feet, measured from equipment extremity and extremity of piping system including flanges, valve bodies or mechanisms, insulation, or hanger/support systems.
 - 3. From Adjacent Work: Minimum 1 inch from nearest extremity of completed piping system including flanges, valve bodies or mechanisms, insulation, or hanger/support systems.
 - 4. Do not route piping in front of or to interfere with access ways, ladders, stairs, platforms, walkways, openings, doors, or windows.
 - 5. Headroom in front of openings, doors, and windows shall not be less than the top of the opening.
 - 6. Do not install piping containing liquids or liquid vapors in transformer vaults or electrical equipment rooms.
 - 7. Do not route piping over, around, in front of, in back of, or below electrical equipment including controls, panels, switches, terminals, boxes, or other similar electrical work.

3.05 SLAB, FLOOR, WALL, AND ROOF PENETRATIONS

- A. Application and Installation: As specified in Section 40 27 01, Process Piping Specialties.

3.06 BRANCH CONNECTIONS

- A. Do not install branch connections smaller than 1/2-inch nominal pipe size, including instrument connections, unless shown otherwise.

- B. When line of lower pressure connects to a line of higher pressure, requirements of Piping Data Sheet for higher pressure rating prevails up to and including first block valve in the line carrying the lower pressure, unless otherwise shown.
- C. Threaded Pipe Tap Connections:
 - 1. Ductile Iron Piping: Connect only with service saddle or at tapping boss of a fitting, valve body, or equipment casting.
 - 2. Limitations: Threaded taps in pipe barrel are unacceptable.

3.07 VENTS AND DRAINS

- A. Vents and drains at high and low points in piping required for completed system may or may not be shown. Install vents on high points and drains on low points of pipelines at all low and high point locations.

3.08 FIELD FINISHING

- A. Notify Engineer at least three days prior to start of surface preparation or coating application work.

3.09 FIELD QUALITY CONTROL

- A. Pressure Leakage Testing: As specified in Section 40 80 01, Process Piping Leakage Testing.

3.10 CLEANING

- A. Following assembly and testing, and prior to final acceptance, flush pipelines, except as stated below, with water at 2.5 fps minimum flushing velocity until foreign matter is removed.
- B. If impractical to flush large diameter pipe at 2.5 fps or blow at 4,000 fpm velocity, clean in-place from inside by brushing and sweeping, then flush or blow line at lower velocity.
- C. Insert cone strainers in flushing connections to attached equipment and leave in-place until cleaning is complete.
- D. Remove accumulated debris through drains 2 inches and larger or by removing spools and valves from piping.

3.11 SUPPLEMENTS

A. The supplements listed below, following “End of Section,” are a part of this Specification:

1. Piping Schedule.
2. Data Sheets.

| Number | Title |
|---------------|---|
| 40 27 00.10 | Polyvinyl Chloride (PVC) Pipe and Fittings |
| 40 27 00.11 | Chlorinated Polyvinyl Chloride (CPVC) Pipe and Fittings |

END OF SECTION

PIPING SCHEDULE LEGEND

EXPOSURE

| | |
|-----|-----------|
| ALL | All |
| EXP | Exposed |
| SUB | Submerged |

MATERIAL

| | |
|------|--------------------|
| CPVC | Chlorinated PVC |
| PVC | Polyvinyl Chloride |

JOINT TYPE

| | |
|----|---------------------------------------|
| FL | Flanged |
| GR | Grooved |
| T | Threaded |
| W | Welded (including solvent and fusion) |

PRESSURE TEST

| | |
|---|---|
| G | Gravity Service: Test pressure is not shown on gravity services. Test to highest liquid level that pipe can be subject to. |
| H | Hydrostatic |

| Piping Schedule | | | | | | | | | |
|---|-----------------------|-------------------|----------|--------------------|-----------------|------------|---|-------------------------|--|
| Service | Label in Drawings | Size(s) (inch) | Exposure | Piping Material | Spec Section | Joint Type | Test Pressure and Type (psig-x), x = Type indicated in Legend | Pipe Label ¹ | Remarks |
| Sodium Hypochlorite Fill or Fill /Transfer | FILL or FILL/TRANSFER | 1, 3 | EXP | CPVC | 40 27 00.11 | W, FL | 125H | HYPO TANK X FILL | |
| Sodium Hypochlorite Pump Skid Pressure Relief | VACUUM RELIEF | 1 | EXP | CPVC | 40 27 00.11 | W, FL | N/A | HYPO VACUUM RELIEF | |
| Sodium Hypochlorite Pump Skid Vacuum Relief | PRESSURE RELIEF | 1 | EXP | CPVC | 40 27 00.11 | W, FL | N/A | HYPO PRESSURE RELIEF | |
| Sodium Hypochlorite Tank Vent | VENT | 6, 10 | EXP | CPVC | 40 27 00.11 | W, FL | G | HYPO VENT | |
| Sodium Hypochlorite Tank Overflow | OVERFLOW | 4 | EXP | CPVC | 40 27 00.11 | W, FL | G | HYPO TANK X OVERFLOW | |
| Sodium Hypochlorite Tank Drain | DRAIN | 3, 4 | EXP | CPVC | 40 27 00.11 | W, FL | G | HYPO TANK X DRAIN | Portion of SHF drain piping is underneath removable grating. |

| Piping Schedule | | | | | | | | | |
|--|--------------------------|---------------------------|-----------------|----------------------------|-------------------------|-------------------|--|---------------------------------------|----------------|
| Service | Label in Drawings | Size(s) (inch) | Exposure | Piping Material | Spec Section | Joint Type | Test Pressure and Type (psig-x), x = Type indicated in Legend | Pipe Label¹ | Remarks |
| Sodium Hypochlorite Recirculation | RECIRCULATION | 3 | EXP | CPVC | 40 27 00.11 | W, FL | 100H | HYPO TANK X RECIRC PUMP SUCTION | |
| Plant Effluent Water | PEW | 2 | EXP | CPVC | 40 27 00.11 | W, FL | 125H | (NON-POTABLE) PEW TO TANK X | |
| Notes: | | | | | | | | | |
| ¹ X = 1 for SHF-HYPO-TANK-01, 2 for SHF-HYPO-TANK-02, 3 for SHF-HYPO-TANK-02 and 3 for SHF-HYPO-TANK-02 piping. | | | | | | | | | |

**SECTION 40 27 00.10
POLYVINYL CHLORIDE (PVC) PIPE AND FITTINGS**

| Item | Size | Description |
|-------------|-------------|---|
| General | All | Materials in contact with potable water shall conform to NSF 61 acceptance. |
| Pipe | All | Schedule 80 PVC: Type I, Grade I or Class 12454-B conforming to ASTM D1784 and ASTM D1785. Pipe shall be manufactured with titanium dioxide for ultraviolet protection. Threads: Schedule 80 special reinforced threaded pipe with metal precompression collar and PVC encapsulation (manufactured by Spears Manufacturing Company, Inc.). |
| Fittings | All | Schedule to Match Pipe Above: ASTM D2466 and ASTM D2467 for socket weld type and Schedule 80 ASTM D2464 for threaded type. Fittings shall be manufactured with titanium dioxide for ultraviolet protection. |
| Joints | All | Solvent socket weld or flanges. |
| Flanges | All | One-piece, molded hub type PVC flat face flange in accordance with Fittings above, ASME B16.1, Class 125 drilling |
| Bolting | All | Material: Grade 2 Titanium or Hastelloy C bolts. |
| Gaskets | All | Flat Face Mating Flange: Full faced 1/8-inch-thick viton (for hypo service) or ethylene propylene (EPR) rubber (for non-hypo service). Raised Face Mating Flange: Flat ring 1/8-inch viton (for hypo service) or ethylene propylene (EPR) rubber (for non-hypo service), with filler gasket between OD of raised face and flange OD to protect the flange from bolting moment. |

**SECTION 40 27 00.10
POLYVINYL CHLORIDE (PVC) PIPE AND FITTINGS**

| Item | Size | Description |
|------------------|-------------|--|
| Solvent Cement | All | Socket type joints shall be made employing solvent cement that meets or exceeds the requirements of ASTM D2564 and primer that meets or exceeds requirements of ASTM F656, chemically resistant to the fluid service, and as recommended by pipe and fitting manufacturer, except solvent weld cement for PVC pipe joints in sodium hypochlorite service shall be free of silica filler and shall be certified by the manufacturer to be suitable for that service, IPS Weld-On 724 or approved equal. Certification shall be submitted. |
| Thread Lubricant | All | Teflon Tape. |

END OF SECTION

**SECTION 40 27 00.11
CHLORINATED POLYVINYL CHLORIDE (CPVC) PIPE AND
FITTINGS**

| Item | Size | Description |
|-------------|-------------|---|
| Pipe | All | Schedule 80 CPVC: Type IV, Grade I or Class 23447-B conforming to ASTM D1784 and ASTM F441/F441M. Pipe shall be manufactured with titanium dioxide for ultraviolet protection. Threads: Schedule 80 special reinforced threaded pipe with metal precompression collar and CPVC encapsulation (manufactured by Spears Manufacturing Company, Inc.). |
| Fittings | All | Schedule to Match Pipe Above: Conforming to the requirements of ASTM F439 for socket weld type and Schedule 80 ASTM F437 for threaded type. Fittings shall be manufactured with titanium dioxide for ultraviolet protection. |
| Joints | All | Solvent socket weld or flanges. |
| Flanges | All | One piece, molded hub Type CPVC flat face flange in accordance with Fittings above; ASME B16.1, Class 125 drilling. |
| Bolting | All | Material: Grade 2 Titanium or Hastelloy C bolts. |
| Gaskets | All | Flat Face Mating Flange: Full faced 1/8-inch-thick viton (for hypo service) or ethylene propylene (EPR) rubber (for non-hypo service). Raised Face Mating Flange: Flat ring 1/8-inch viton (for hypo service) or ethylene propylene (EPR) rubber (for non-hypo service), with filler gasket between OD of raised face and flange OD to protect the flange from bolting moment. |

**SECTION 40 27 00.11
CHLORINATED POLYVINYL CHLORIDE (CPVC) PIPE AND
FITTINGS**

| Item | Size | Description |
|------------------|-------------|--|
| Solvent Cement | All | All socket type joints shall be made employing primer and solvent cements that meet or exceed the requirements of ASTM F493 and primers that meet or exceed the requirements of ASTM F656, resistant to the fluid service, and as recommended by the pipe and fitting manufacturer, except solvent weld cement for CPVC pipe joints in sodium hypochlorite service shall be free of silica filler and shall be certified by the manufacturer to be suitable for that service, IPS Weld-On 724 or approved equal. Certification shall be submitted. |
| Thread Lubricant | All | Teflon tape. |

END OF SECTION

SECTION 40 27 01
PROCESS PIPING SPECIALTIES

PART 1 GENERAL

1.01 REFERENCES

- A. The following is a list of standards which may be referenced in this section:
1. American Society of Mechanical Engineers (ASME):
 - a. B16.1, Gray Iron Pipe Flanges and Flanged Fittings (Classes 25, 125, and 250).
 - b. B16.5, Pipe Flanges and Flanged Fittings: NPS 1/2 through NPS 24 Metric/Inch Standard.
 2. ASTM International (ASTM):
 - a. A153/A153M, Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.
 - b. A276, Standard Specification for Stainless Steel Bars and Shapes.
 3. National Fire Protection Association (NFPA): 24, Standard for the Installation of Private Fire Service Mains and Their Appurtenances.
 4. NSF International (NSF):
 - a. NSF/ANSI 61, Drinking Water System Components - Health Effects.
 - b. NSF/ANSI 372, Drinking Water System Components - Lead Content.

1.02 SUBMITTALS

- A. Action Submittals: Manufacturer's data on materials, construction, end connections, ratings, overall lengths, and live lengths (as applicable).
- B. Informational Submittals: Operation and Maintenance Manuals as specified in Section 01 78 23, Operation and Maintenance Manuals.

PART 2 PRODUCTS

2.01 GENERAL

- A. Provide required piping specialty items, whether shown or not shown on Drawings, as required by applicable codes and standard industry practice.
- B. Rubber ring joints, mechanical joints, flexible couplings, and proprietary restrained ductile iron pipe joints are considered flexible joints; welded, screwed, and flanged pipe joints are not considered flexible.
- C. Components and Materials in Contact with Water for Human Consumption: Comply with the requirements of the Safe Drinking Water Act and other

applicable federal, state, and local requirements. Provide certification by manufacturer or an accredited certification organization recognized by the Authority Having Jurisdiction that components and materials comply with the maximum lead content standard in accordance with NSF/ANSI 61 and NSF/ANSI 372.

1. Use or reuse of components and materials without a traceable certification is prohibited.

2.02 CONNECTORS

A. Quick Connect Couplings for Chemical Services:

1. Type: Twin cam arm actuated, male and female, locking, for chemical loading and transfer.
2. Materials: Glass-filled polypropylene or PVDF with EPDM, Viton-A or Teflon gaskets as recommended for the service by manufacturer.
3. End Connections: NPT threaded or flanged to match piping connections. Hose shank for chemical installations.
4. Plugs and Caps: Female dust cap for each male end; male dust plug for each female end.
5. Pressure Rating: 125 psi, minimum, at 70 degrees F.
6. Manufacturers and Products:
 - a. OPW; Kamlock.
 - b. Ryan Herco; 1300 Series.

2.03 COUPLINGS

A. General:

1. Coupling linings for use in potable water systems shall be in conformance with NSF/ANSI 61.
2. Couplings shall be rated for working pressure not less than indicated in Piping Schedule for the service and not less than 150 psi.
3. Couplings shall be lined and coated with liquid epoxy in accordance with AWWA C210.
4. Unless thrust restraint is provided by other means, couplings shall be harnessed in accordance with requirements of AWWA Manual M11 or as shown on Drawings.
5. Sleeve type couplings shall conform to AWWA C219 and shall be hydraulically expanded beyond minimum yield for accurate sizing and proofing of tensile strength.

B. Restrained Flange Adapter:

1. Pressure Rating:
 - a. Minimum Working Pressure Rating: Not less than 150 psi.
 - b. Safety Factor: Not less than two times working pressure and shall be supported by manufacturer's proof testing.
2. Thrust Restraint:
 - a. Provide hardened steel wedges that bear against and engage outer pipe surface and allow articulation of pipe joint after assembly while wedges remain in their original setting position on pipe surface.
 - b. Products employing set screws that bear directly on pipe will not be acceptable.
3. Manufacturer and Product: EBAA Iron Sales Co.; Mega-Flange.

2.04 SERVICE SADDLES

A. Double-Strap Iron:

1. Pressure Rating: Capable of withstanding 150 psi internal pressure without leakage or over stressing.
2. Run Diameter: Compatible with outside diameter of pipe on which saddle is installed.
3. Taps: Iron pipe threads.
4. Materials:
 - a. Body: Malleable or ductile iron.
 - b. Straps: Galvanized steel.
 - c. Hex Nuts and Washers: Steel.
 - d. Seal: Rubber.
5. Manufacturers and Products:
 - a. Smith-Blair; Series: 313 or 366.
 - b. Dresser; Style 91.

B. Nylon-Coated Iron:

1. Pressure Rating: Capable of withstanding 150 psi internal pressure without leakage or over stressing.
2. Run Diameter: Compatible with outside diameter of pipe on which saddle is installed.
3. Materials:
 - a. Body: Nylon-coated iron.
 - b. Seal: Buna-N.
 - c. Clamps and Nuts: Stainless steel.
4. Manufacturer: Smith-Blair; Style 315 or 317.

2.05 PIPE SLEEVES

A. Modular Mechanical Seal:

1. Type: Interconnected synthetic rubber links shaped and sized to continuously fill annular space between pipe and wall sleeve opening.
2. Fabrication:
 - a. Assemble interconnected rubber links with ASTM A276, Type 316 stainless steel bolts and nuts.
 - b. Pressure plates shall be reinforced nylon polymer.
3. Size: According to manufacturer's instructions for size of pipes shown to provide a watertight seal between pipe and wall sleeve opening, and to withstand a hydrostatic head of 40 feet of water.
4. Manufacturer: Thunderline Corp., Link-Seal Division.

PART 3 EXECUTION

3.01 GENERAL

- A. Provide accessibility to piping specialties for control and maintenance.

3.02 PIPING FLEXIBILITY PROVISIONS

- A. General: Install flexible couplings to facilitate piping installation, in accordance with approved shop drawings.

3.03 PIPING TRANSITION

A. Applications:

1. Provide complete closure assembly where pipes meet other pipes or structures.
2. Restrained Joint Pipe Closures: Install with thrust tie-rod assemblies as shown or in accordance with NFPA 24.
3. Elastomer sleeves bonded to pipe ends are not acceptable.

B. Installation:

1. Flexible Transition Couplings: Install in accordance with coupling manufacturer's instructions to connect dissimilar pipe and pipes with a small difference in outside diameter.

3.04 SERVICE SADDLES

- A. Plastic Piping: Nylon-coated iron.

3.05 COUPLINGS

A. General:

1. Install in accordance with manufacturer's written instructions.
2. Before coupling, clean pipe holdback area of oil, scale, rust, and dirt.
3. Application:
 - a. Metallic Piping Systems: Flexible couplings, transition couplings, and flanged coupling adapters.
 - b. Concrete Encased Couplings: Flexible coupling.

3.06 SLAB, FLOOR, WALL AND ROOF PENETRATIONS

A. Applications:

1. Watertight and Below Ground Penetrations:
 - a. Wall pipes with thrust collars.
 - b. Provide taps for stud bolts in flanges to be set flush with wall face.
2. Nonwatertight Penetrations: Pipe sleeves with seep ring.
3. Existing Walls: Rotary drilled holes.
4. Fire-Rated or Smoke-Rated Walls, Floors or Ceilings: Insulated and encased pipe sleeves.

END OF SECTION

SECTION 40 27 02
PROCESS VALVES AND OPERATORS

PART 1 GENERAL

1.01 REFERENCES

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

1. American Water Works Association (AWWA):
 - a. C512, Air-Release, Air/Vacuum, and Combination Air Valves for Waterworks Service.
2. ASTM International (ASTM):
 - a. A276, Standard Specification for Stainless Steel Bars and Shapes.
 - b. A351/A351M, Standard Specification for Castings, Austenitic, for Pressure-Containing Parts.
 - c. A380, Standard Practice for Cleaning, Descaling, and Passivation of Stainless Steel Parts, Equipment, and Systems.
 - d. A564/A564M, Standard Specification for Hot-Rolled and Cold-Finished Age-Hardening Stainless Steel Bars and Shapes.
 - e. B61, Standard Specification for Steam or Valve Bronze Castings.
 - f. B62, Standard Specification for Composition Bronze or Ounce Metal Castings.
 - g. B98/B98M, Standard Specification for Copper-Silicon Alloy Rod, Bar, and Shapes.
 - h. B127, Standard Specification for Nickel-Copper Alloy (UNS N04400) Plate, Sheet, and Strip.
 - i. B139/B139, Standard Specification for Phosphor Bronze Rod, Bar and Shapes.
 - j. B164, Standard Specification for Nickel-Copper Alloy Rod, Bar, and Wire.
 - k. B194, Standard Specification for Copper-Beryllium Alloy Plate, Sheet, Strip, and Rolled Bar.
 - l. B584, Standard Specification for Copper Alloy Sand Castings for General Applications.
 - m. D429, Standard Test Methods for Rubber Property-Adhesion to Rigid Substrates.
 - n. D1784, Standard Specification for Rigid Poly(Vinyl Chloride) (PVC) Compounds and Chlorinated Poly(Vinyl Chloride) (CPVC) Compounds.
3. Manufacturers Standardization Society (MSS):
 - a. SP-80, Bronze Gate, Globe, Angle, and Check Valves.
 - b. SP-81, Stainless Steel, Bonnetless, Flanged Knife Gate Valves.
 - c. SP-85, Gray Iron Globe and Angle Valves, Flanged and Threaded Ends.

- d. SP-88, Diaphragm Valves.
- e. SP-110, Ball Valves Threaded, Socket-Welding, Solder Joint, Grooved and Flared Ends.

1.02 SUBMITTALS

A. Action Submittals:

- 1. Shop Drawings:
 - a. Product data sheets for each make and model. Indicate valve Type Number, applicable Tag Number, and facility name/number or service where used.
 - b. Complete catalog information, descriptive literature, specifications, and identification of materials of construction.
 - c. Certification for compliance to NSF/ANSI 61 for valves used for drinking water service.
 - d. Power and control wiring diagrams, including terminals and numbers.
 - e. For each power actuator provided, manufacturer's standard data sheet, with application specific features and options clearly identified.
 - f. Sizing calculations for open-close/throttle and modulating valves.

B. Informational Submittals:

- 1. Manufacturer's Certificate of Compliance, in accordance with Section 01 61 00, Common Product Requirements, for:
 - a. Electric actuators; full compliance with AWWA C542.
- 2. Operation and Maintenance Manuals as specified in Section 01 78 23, Operation and Maintenance Manuals.
- 3. Manufacturer's Certificate of Proper Installation, in accordance with Section 01 43 33, Manufacturers' Field Services.

1.03 WARRANTY

- A. Provide manufacturer's extended warranty in writing with Owner named as beneficiary. Warranty shall provide for correction, or removal and replacement of products found defective during the stated period after date of Substantial Completion as specified in the General Conditions.

PART 2 PRODUCTS

2.01 GENERAL

- A. Valves to include operator, actuator, handwheel, chain wheel, extension stem, floor stand, operating nut, chain, wrench, and accessories to allow a complete operation from the intended operating level.
- B. Valve to be suitable for intended service. Renewable parts not to be of a lower quality than specified.
- C. Valve same size as adjoining pipe, unless otherwise called out on Drawings or in Supplements.
- D. Valve ends to suit adjacent piping.
- E. Resilient seated valves shall have no leakage (drip-tight) in either direction at valve rated design pressure. All other valves shall have no leakage (drip-tight) in either direction at valve rated design pressure, unless otherwise allowed for in this section or in stated valve standard.
- F. Size operators and actuators to operate valve for full range of pressures and velocities.
- G. Valve to open by turning counterclockwise, unless otherwise specified.
- H. Factory mount operator, actuator, and accessories.
- I. Components and Materials in Contact with Water for Human Consumption: Comply with the requirements of the Safe Drinking Water Act and other applicable federal, state, and local requirements. Provide certification by manufacturer or an accredited certification organization recognized by the Authority Having Jurisdiction that components and materials comply with the maximum lead content standard in accordance with NSF/ANSI 61 and NSF/ANSI 372.
 - 1. Use or reuse of components and materials without a traceable certification is prohibited.

2.02 SCHEDULE

- A. Additional requirements relative to this section are shown on Valve Schedules located at the end of this section.

2.03 FACTORY FINISHING

- A. General: Exposed safety isolation valves and lockout valves with handles, handwheels, or chain wheels shall be “safety yellow.”

2.04 VALVES

A. Ball Valves:

1. Type V330 CPVC Ball Valve:
 - a. Rated for at least 150 psi at 73 degrees F, with ASTM D1784, Cell classification 23567-A, chlorinated polyvinyl chloride body, ball, and stem, end entry, double union design, solvent-weld socket ends, elastomer seat, Viton or Teflon O-ring stem seals, to block flow in both directions. Provide pressure relief hole factory-drilled on low pressure side of ball.
 - b. Manufacturers and Products:
 - 1) Nibco.
 - 2) ASAHI/America.
 - 3) Spears.
 - 4) Hayward.
2. Type V331 PVC Ball Valve:
 - a. Rated 150 psi at 73 degrees F, with ASTM D1784 Type I, Grade 1 PVC full port body, Teflon seat, Viton O-ring stem, face and carrier seals, end entry design with dual union, solvent-weld socket ends, or single union ball valve with flanged ends drilled to ASME B16.1. Provide pressure relief hole drilled on low pressure side of ball.
 - b. Manufacturers and Products:
 - 1) Nibco.
 - 2) ASAHI/America.
 - 3) Hayward.

B. Pressure Relief Valves

1. Thermoplastic Pressure Relief Valves:
 - a. Construction: PVC or CPVC to match process piping.
 - b. End Connection: Threaded with Type 316 stainless steel outer reinforcing.
 - c. Seals: Material shall be completely compatible with process liquid.
 - d. Features:
 - 1) Settings: 5-75 psi.
 - 2) 150 psig rating.
 - e. Manufacturers: Hayward, or approved equal.

2.05 OPERATORS AND ACTUATORS

A. Manual Operators:

1. General:

- a. For AWWA valves, operator force not to exceed requirements of applicable valve standard. Provide gear reduction operator when force exceeds requirements.
- b. For nonAWWA valves, operator force not to exceed applicable industry standard or 80 pounds, whichever is less, under operating condition, including initial breakaway. Provide gear reduction operator when force exceeds requirements.
- c. Operator self-locking type or equipped with self-locking device.
- d. Position indicator on quarter-turn valves.
- e. Worm and gear operators one-piece design, worm-gears of gear bronze material. Worm of hardened alloy steel with thread ground and polished. Traveling nut type operator's threaded steel reach rod with internally threaded bronze or ductile iron nut.

2. Exposed Operator:

- a. Galvanized and painted handwheel.
- b. Cranks on gear type operator.
- c. Chain wheel operator with tieback, extension stem, floor stand, and other accessories to permit operation from normal operation level.
- d. Valve handles to take a padlock and wheels a chain and padlock.

B. Electric Motor Actuators, 120 Volts Single-phase:

1. General:

- a. Comply with latest version of AWWA C542.
- b. Size to 1-1/2 times required operating torque. Motor stall torque not to exceed torque capacity of valve.
- c. Controls integral with actuator and fully equipped as specified in AWWA C542.
- d. Stem protection for rising stem valves.
- e. To maintain the integrity of the enclosure, setting of the torque levels, position limits and configuration of the indication contacts etc., shall be carried out without the removal of any actuator covers and without mains power using a *Bluetooth*® wireless setting tool. Sufficient commissioning tools shall be provided with the actuators and must meet the enclosure protection and certification levels of the actuators. Commissioning tools shall not form an integral part of the actuator and must be removable for secure storage/authorized release. In addition, provision shall be made for the protection of configured actuator settings by a means independent of access to the commissioning tool. Provision shall

be made to disable *Bluetooth*® communications or only allow a *Bluetooth*® connection initiated by an infra-red command for maximum security. A Bluetooth setting tool shall be provided with each single actuator order.

2. Actuator Operation—General:
 - a. Suitable for full 90-degree rotation of quarter-turn valves or for use on multiturn valves, as applicable.
 - b. Manual override handwheel.
 - c. Valve position indication.
 - d. Operate from FULL CLOSED to FULL OPEN positions or the reverse in the number of seconds given in Valve Schedule.
3. Protection Control:
 - a. Torque Limiting Switches: Two single-pole, double-throw (SPDT) mechanical switches. Switches operate at any point in valve travel.
 - b. Jammed-valve detection and protection.
 - c. Motor over-temperature detection and protection.
 - d. Travel limit switches, SPDT.
 - e. Provide 120V ac SPDT dry fault relay to trip for the following reasons:
 - 1) Loss of one or more phases of the 3-phase power supply.
 - 2) Loss of internal control power.
 - 3) Valve Jammed condition is detected.
 - 4) Motor Overtemp (unless the thermistor is configured to Off).
4. Provide 120V ac SPDT dry relay when in REMOTE.
5. Open-Close (O/C) Service as Indicated in Valve Schedule:
 - a. Size motors for 60 starts per hour.
 - b. Integral reversing motor starter with built-in overload protection.
 - c. Controls on local actuator:
 - 1) LOCAL-OFF-REMOTE (L-O-R) selector switch, padlockable in each position:
 - 2) In LOCAL position of L-O-R, local OPEN-STOP-CLOSE momentary pushbuttons/spring return selector switch to control valve.
 - 3) In REMOTE position of L-O-R, actuator shall be controlled by OPEN command - CLOSE command as dry contact inputs from remote PLC/RIO panel. Integral seal-in circuits for remote OPEN and CLOSE commands not required; valve travel stops when both remote OPEN-CLOSE contact opens.
 - 4) Auxiliary 120V ac dry contact rated minimum 10 amps at 120V ac that closes when L-O-R in REMOTE position.
 - 5) Auxiliary dry contacts rated minimum 10 amps at 120V ac that closes when valve is in FULL OPEN (adjustable) or FULL CLOSED (adjustable) positions.

- 6) OPEN and CLOSED indicating lights or LCD display.
 - 7) When used with remote control station, the REMOTE position of the selector switch on the actuator transfers control of the actuator to the remote control station.
- d. Valve with Remote Control Station:
- 1) Allows remote monitoring and control of valve by duplicating actuator mounted control station.
 - 2) Powered from associated actuator.
 - 3) Provide LOCAL-OFF-REMOTE selector switch, padlockable in each position.
 - 4) Provide OPEN-STOP-CLOSE momentary pushbutton or selector switch to control valve locally from remote control station only when actuator mounted L-O-R in REMOTE position and remote control station mounted L-O-R in Local position.
 - 5) Display valve full OPEN and full CLOSED positions with lights or LCD display.
 - 6) Provide auxiliary dry contact rated minimum 10 amps at 120V ac for monitoring of valve fully open position and valve fully close position via remote PLC/RIO.
 - 7) With Remote Control Station-provided Valve Actuator:
 - a) Remote Status Monitoring: Provide auxiliary dry contact rated minimum 10 amps at 120V ac that closes only When L-O-R on the actuator and L-O-R on the remote control station are in the REMOTE position.
 - b) Remote Control: Actuator shall be controlled by OPEN command - CLOSE command as dry contact inputs from remote PLC/RIO panel only, when L-O-R on the actuator and L-O-R on the remote control station are in the REMOTE position.
 - c) Enclosure: NEMA 4X/6.
 - 8) Provide remote control station as indicated in Valve Schedule.
6. Actuator Power Supply:
- a. 120 volts, single phase as noted in Valve Schedule.
 - b. Control power shall be 120-volt.
7. Failsafe Battery:
- a. Actuators shall include an internal lithium-ion shutdown battery for failsafe operation on loss of main power supply. On loss of main power supply, the shutdown battery-fitted actuator shall allow the user to configure the actuator to drive open, closed, or stay put using the hand-held setting tool. The shutdown battery shall reside inside the electrical compartment of the actuator. The shutdown battery shall include a UPS mode that allows the actuator to operate normally to the end of the battery charge. The

shutdown battery will automatically recharge when the main power supply to the actuator is in its normal, energized state. When the main power supply is restored to the actuator, the actuator will automatically return to its normal state of operation. The shutdown battery charge level can be monitored locally at the actuator and remotely via a feedback signal from the actuator.

- b. Provide shutdown battery as indicated on valve schedule.
8. Enclosure:
 - a. NEMA 4X/6.
 - b. SPDT type, field-adjustable, with contacts rated for 5 amps at 120Vac.
 - c. Each valve actuator to have a minimum of two auxiliary transfer contacts at end position, one for valve FULL OPEN and one for valve FULL CLOSED.
 - d. Housed in actuator control enclosure.
9. Control Features: Electric motor actuators with features as noted above and as indicated in Valve Schedule.
10. Manufacturers: Rotork Controls, IQT Series.

2.06 ACCESSORIES

- A. Tagging: 1-1/2-inch diameter heavy brass or stainless steel tag attached with No. 16 solid brass or stainless steel jack chain for each valve operator, bearing valve tag number shown on Valve Schedule.
- B. Chain Wheel and Guide:
 1. Handwheel direct-mount type.
 2. Complete with chain.
 3. Galvanized or cadmium plated.
 4. Manufacturers and Products:
 - a. Clow Corp.; Figure F-5680.
 - b. Walworth Co.; Figure 804.
 - c. DeZurik Corp.; Series W or LWG.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Flange Ends:
 1. Flanged valve bolt holes shall straddle vertical centerline of pipe.
 2. Clean flanged faces, insert gasket and bolts, and tighten nuts progressively and uniformly.

- B. Screwed Ends:
 - 1. Clean threads by wire brushing or swabbing.
 - 2. Apply joint compound.
- C. PVC and CPVC Valves: Install using solvents approved for valve service conditions.
- D. Valve Installation and Orientation:
 - 1. General:
 - a. Install valves so handles operate from fully open to fully closed without encountering obstructions.
 - b. Install valves in location for easy access for routine operation and maintenance.
 - c. Install valves per manufacturer's recommendations.
 - 2. Ball Valves:
 - a. Install operating stem vertical when valve is installed in horizontal runs of pipe having centerline elevations 4 feet 6 inches or less above finished floor, unless otherwise shown.
 - b. Install operating stem horizontal in horizontal runs of pipe having centerline elevations greater than 4 feet 6 inches above finish floor, unless otherwise shown.
- E. Locate valve to provide accessibility for control and maintenance. Install access doors in finished walls and plaster ceilings for valve access.
- F. Chain Wheel and Guide: Install chain wheel and guide assemblies or chain lever assemblies on manually operated valves over 6 feet 9 inches above finish floor. Install chain to within 3 feet of finish floor. Where chains hang in normally traveled areas, use appropriate "L" type tie-back anchors. Install chains to within operator horizontal reach of 2 feet 6 inches maximum, measured from normal operator standing location or station.

3.02 TESTS AND INSPECTION

- A. Valve may be either tested while testing pipelines, or as a separate step.
- B. Test that valves open and close smoothly under operating pressure conditions. Test that two-way valves open and close smoothly under operating pressure conditions from both directions.
- C. Count and record number of turns to open and close valve, account for discrepancies with manufacturer's data.
- D. Set, verify, and record set pressures for relief and regulating valves.

3.03 SUPPLEMENTS

- A. The supplements listed below, following “End of Section,” are part of this Specification.
 - 1. Valve Schedule.

END OF SECTION

| Valve Schedule | | | | | | | | | |
|-------------------------------|------------|------------|------------------------|---------------------|---------------------|--|---------|-----------------------|--|
| Valve Name | Tag Number | Valve Type | Actuator Power Supply | Valve Size (inches) | Process Fluid | Maximum Operating Flow (gpm) and Pressure Drop (psi) | Service | Travel Time (seconds) | Control Feature Modifications/ Supplements |
| NFF-VALVE-TANK-OUTLET | MV-245 | V330 | 120-volt, single phase | 3 | Sodium Hypochlorite | 10 gpm, 1 psi | O/C | 15 to 20 | D, G, I, J, K |
| SHF-VALVE-TANK-OUTLET-01 | MV-90 | V330 | 120-volt, single phase | 3 | Sodium Hypochlorite | 125 gpm, 5 psi | O/C | 15 to 20 | D, G, I, J |
| SHF-VALVE-TANK-OUTLET-02 | MV-100 | V330 | 120-volt, single phase | 3 | Sodium Hypochlorite | 125 gpm, 5 psi | O/C | 15 to 20 | D, G, I, J |
| SHF-VALVE-TANK-OUTLET-03 | MV-120 | V330 | 120-volt, single phase | 3 | Sodium Hypochlorite | 125 gpm, 5 psi | O/C | 15 to 20 | D, G, I, J |
| SHF-VALVE-TANK-OUTLET-04 | MV-110 | V330 | 120-volt, single phase | 3 | Sodium Hypochlorite | 125 gpm, 5 psi | O/C | 15 to 20 | D, G, I, J |
| SHF-VALVE-SUCT-PUMP-RECIRC-01 | MV-92 | V330 | 120-volt, single phase | 3 | Sodium Hypochlorite | 125 gpm, 5 psi | O/C | 15 to 20 | D, G, I, J |
| SHF-VALVE-SUCT-PUMP-RECIRC-02 | MV-102 | V330 | 120-volt, single phase | 3 | Sodium Hypochlorite | 125 gpm, 5 psi | O/C | 15 to 20 | D, G, I, J |
| SHF-VALVE-SUCT-PUMP-RECIRC-03 | MV-106 | V330 | 120-volt, single phase | 3 | Sodium Hypochlorite | 125 gpm, 5 psi | O/C | 15 to 20 | D, G, I, J |

| Valve Schedule | | | | | | | | | |
|--------------------------------|------------|------------|------------------------|---------------------|---------------------|--|---------|-----------------------|---|
| Valve Name | Tag Number | Valve Type | Actuator Power Supply | Valve Size (inches) | Process Fluid | Maximum Operating Flow (gpm) and Pressure Drop (psi) | Service | Travel Time (seconds) | Control Feature Modifications/Supplements |
| SHF-VALVE-SUCT-PUMP-RECIRC-04 | MV-104 | V330 | 120-volt, single phase | 3 | Sodium Hypochlorite | 125 gpm, 5 psi | O/C | 15 to 20 | D, G, I, J |
| SHF-VALVE-DISCH-PUMP-RECIRC-01 | MV-96 | V330 | 120-volt, single phase | 3 | Sodium Hypochlorite | 125 gpm, 5 psi | O/C | 15 to 20 | D, G, I, J, K |
| SHF-VALVE-DISCH-PUMP-RECIRC-02 | MV-94 | V330 | 120-volt, single phase | 3 | Sodium Hypochlorite | 125 gpm, 5 psi | O/C | 15 to 20 | D, G, I, J, K |
| SHF-VALVE-DISCH-PUMP-RECIRC-03 | MV-98 | V330 | 120-volt, single phase | 3 | Sodium Hypochlorite | 125 gpm, 5 psi | O/C | 15 to 20 | D, G, I, J, K |
| SHF-VALVE-DISCH-PUMP-RECIRC-04 | MV-108 | V330 | 120-volt, single phase | 3 | Sodium Hypochlorite | 125 gpm, 5 psi | O/C | 15 to 20 | D, G, I, J, K |

| Valve Schedule | | | | | | | | | |
|---|------------|------------|-----------------------|---------------------|---------------|--|---------|-----------------------|---|
| Valve Name | Tag Number | Valve Type | Actuator Power Supply | Valve Size (inches) | Process Fluid | Maximum Operating Flow (gpm) and Pressure Drop (psi) | Service | Travel Time (seconds) | Control Feature Modifications/Supplements |
| <p>Service: O/C = Open-Close. Control Feature Modifications/Supplements:</p> <p>A = Actuator shall open valve upon loss of signal.</p> <p>B = Actuator shall close valve upon loss of signal.</p> <p>C = Actuator shall remain in last position upon loss of signal.</p> <p>D = Local OPEN-CLOSE momentary pushbuttons that shall be continuously depressed to initiate/maintain valve travel; travel stops when pushbutton is released or when end of travel limit is reached.</p> <p>E = Remote OPEN-CLOSE maintained dry contacts; travel stops when remote contact opens, or when end of travel limit is reached.</p> <p>F = Three 24V dc interposing relays for remote OPEN-STOP-CLOSE control. Relays powered externally, thereby permitting valve control from greater distances.</p> <p>G = Motor and control enclosure(s) NEMA 250, Type 4X/6</p> <p>H = Valve position output converter that generates isolated 4 to 20 mA dc signal in proportion to valve position and is capable of driving into loads of up to 500 ohms at 24V dc.</p> <p>I = 120-volt secondary control power transformer.</p> <p>J = Externally operable power fused disconnect switch.</p> <p>K = Provide remote control station.</p> <p>L = Failsafe battery.</p> | | | | | | | | | |

SECTION 40 80 01
PROCESS PIPING LEAKAGE TESTING

PART 1 GENERAL

1.01 SUBMITTALS

A. Informational Submittals:

1. Testing Plan:
 - a. Submit prior to testing and include at least the information that follows.
 - 1) Testing dates.
 - 2) Piping systems and section(s) to be tested.
 - 3) Test type.
 - 4) Method of isolation.
 - 5) Calculation of maximum allowable leakage for piping section(s) to be tested.
2. Certifications of Calibration: Testing equipment.
3. Certified Test Report with testing results.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.01 PREPARATION

A. Notify Engineer in writing five days in advance of testing. Perform testing in presence of Engineer.

B. Pressure Piping:

1. Install temporary restraint as necessary to protect adjacent piping or equipment and make taps in piping prior to testing.
2. Prior to test, remove or suitably isolate appurtenant instruments or devices that could be damaged by pressure testing.
3. New Piping Connected to Existing Piping:
 - a. Isolate new piping with grooved-end pipe caps, spectacle blinds, blind flanges, or as acceptable to Engineer.
 - b. Test joint between new piping and existing piping by methods that do not place entire existing system under test load, as approved by Engineer.
4. Items that do not require testing include piping between wetwells and wetwell isolation valves, equipment seal drains, tank overflows to atmospheric vented drains, and tank atmospheric vents.
5. Test Pressure: As indicated on Piping Schedule.

- C. Test section may be filled with water and allowed to stand under low pressure prior to testing.

3.02 HYDROSTATIC TEST FOR PRESSURE PIPING

- A. Fluid: Clean water of such quality to prevent corrosion of materials in piping system.
- B. Exposed Piping:
 - 1. Perform testing on installed piping prior to application of insulation.
 - 2. Maximum Filling Velocity: 0.25 foot per second, applied over full area of pipe.
 - 3. Vent piping during filling. Open vents at high points of piping system or loosen flanges, using at least four bolts, or use equipment vents to purge air pockets.
 - 4. Maintain hydrostatic test pressure continuously for 30 minutes, minimum, and for such additional time as necessary to conduct examinations for leakage.
 - 5. Examine joints and connections for leakage.
 - 6. Correct visible leakage and retest as specified.
 - 7. Empty pipe of water prior to final cleaning or disinfection.
- C. Defective Piping Sections: Place or test and seal individual joints, and retest as specified.

3.03 FIELD QUALITY CONTROL

- A. Test Report Documentation:
 - 1. Test date.
 - 2. Description and identification of piping tested.
 - 3. Test fluid.
 - 4. Test pressure.
 - 5. Remarks, including:
 - a. Leaks (type, location).
 - b. Repair/replacement performed to remedy excessive leakage.
 - 6. Signed by Contractor and Engineer to represent that test has been satisfactorily completed.

END OF SECTION

SECTION 40 90 01
INSTRUMENTATION AND CONTROL FOR PROCESS SYSTEMS

PART 1 GENERAL

1.01 REFERENCES

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

1. ASTM International (ASTM):
 - a. A182, Standard Specification for Forged or Rolled Alloy-Steel Pipe Flanges, Forged Fittings, and Valves and Parts for High-Temperature Service.
 - b. A276, Standard Specification for Stainless and Heat-Resisting Steel Bars and Shapes.
 - c. A312, Standard Specification for Seamless and Welded Austenitic Stainless Steel Pipes.
 - d. B32, Standard Specification for Solder Metal.
 - e. B88, Standard Specification for Seamless Copper Water Tube.
2. International Society of Automation (ISA):
 - a. S5.1, Instrumentation Symbols and Identification (NRC ADOPTED).
 - b. PR12.6, Installation of Intrinsically Safe Systems for Hazardous (Classified) Locations.
 - c. S5.4, Standard Instrument Loop Diagrams.
 - d. S20, Specification Forms for Process Measurement and Control Instruments, Primary Elements and Control Valves.
 - e. S50.1, Compatibility of Analog Signals for Electronic Industrial Process Instruments.
3. National Electrical Manufacturers Association (NEMA):
 - a. 250, Enclosures for Electrical Equipment (1,000 Volts Maximum).
 - b. ICS 1, General Standards for Industrial Control and Systems.
4. National Institute of Standards and Technology (NIST).
5. NSF International (NSF):
 - a. NSF/ANSI 61, Drinking Water System Components - Health Effects.
 - b. NSF/ANSI 372, Drinking Water System Components - Lead Content.
6. UL: 508A, Standard for Safety, Industrial Control Panels.

1.02 SUMMARY

A. Work Includes:

1. Engineering, furnishing, installing, calibrating, adjusting, testing, documenting, starting up, and Owner training for the modified process

instrumentation and control (PIC) at the Arlington Water Pollution Plant.

2. Major parts are:
 - a. Primary elements, transmitters, and control devices.
 - b. Modifications to the following existing control panels as specified herein and as shown on the Drawings:
 - 1) DCU-NFF.
 - 2) NFF-PANL-FILL-NaOH/NaOCL.
 - 3) SHF-RIO.
 - 4) SHF-PANL-FILL HYPO 1.
 - 5) SHF-PANL-FILL HYPO-2.
 - 6) Rescale all existing digital display for each tank level in NFF-PANL-FILL-NaOH/NaOCL, SHF-PANL-FILL HYPO 1 and SHF-PANL-FILL HYPO-2.
- B. Detailed Design: PIC as shown and specified includes functional and performance requirements and component specifications. Complete detailed PIC design.

1.03 DEFINITIONS

- A. Abbreviations:
 1. LAP: Local alarm panel.
 2. MCP: Motor control panel.
 3. PAT: Performance acceptance test.
 4. PIC: Process instrumentation and control.
 5. PLC: Programmable logic controller.
- B. Rising/Falling: Terms used to define actions of discrete devices about their setpoints.
 1. Rising: Contacts close when an increasing process variable rises through setpoint.
 2. Falling: Contacts close when a decreasing process variable falls through setpoint.
- C. Signal Types:
 1. Analog Signals, Current Type:
 - a. 4 mA to 20 mA dc signals conforming to ISA S50.1.
 - b. Unless otherwise indicated for specific PIC Subsystem components, use the following ISA 50.1 options:
 - 1) Transmitter Type: Number 2, two-wire.
 - 2) Transmitter Load Resistance Capacity: Class L.
 - 3) Fully isolated transmitters and receivers.

2. Analog Signals, Voltage Type: 1 to 5 volts dc within panels where a common high precision dropping resistor is used.
3. Discrete signals, two-state logic signals using dc or 120V ac sources as indicated.
4. Pulse Frequency Signals:
 - a. Direct current pulses whose repetition rate is linearly proportional to process variable.
 - b. Pulses generated by contact closures or solid state switches as indicated.
 - c. Power source less than 30V dc.
5. Special Signals: Other types of signals used to transmit analog and digital information between field elements, transmitters, receivers, controllers, and digital devices.

D. Instrument Tag Numbers:

1. A shorthand tag number notation is used in the Loop Specifications. For example: AI-1-2(2)(3)[pH].

| Notation | Explanation |
|-----------------|---|
| AI | ISA designator for Analysis Indicator. |
| 1 | Unit process number. |
| 2 | Loop number. |
| (2) | First unit number; number of same component types in a given loop; -1 and -2 in this example. |
| (3) | Second unit number; number of same component types with same first unit number in a given loop; -1, -2, and -3 in this example. |
| [pH] | Same notation shown at 2 o'clock position on ISA circle symbol on P&ID. |

2. In this example, AI-1-12(2)(3)[pH] is shorthand for:

AI-1-12-1-1[pH], AI-1-12-1-2[pH], AI-1-12-1-3[pH]
 AI-1-12-2-1[pH], AI-1-12-2-2[pH], AI-1-12-2-3[pH]

1.04 SUBMITTALS

A. Action Submittals:

1. General:
 - a. Shop Drawings, full-scaled details, wiring diagrams, catalog cuts, and descriptive literature.

- b. Identify proposed items and options. Identify installed spares and other provisions for future work (for example, reserved panel space; unused components, wiring, and terminals).
 - c. Legends and Abbreviation Lists: Complete definition of symbols and abbreviations used on this Project (for example, engineering units, flow streams, instruments, structures, and other process items used in nameplates, legends, and data sheets).
- 2. Bill of Materials: List of required equipment.
 - a. Group equipment items as follows:
 - 1) I&C Components: By component identification code.
 - 2) Other Equipment: By equipment type.
 - b. Data Included:
 - 1) Equipment tag number.
 - 2) Description.
 - 3) Manufacturer, complete model number, and all options not defined by model number.
 - 4) Quantity supplied.
 - 5) Component identification code where applicable.
- 3. Catalog Cuts: I&C Components, Electrical Devices, and Mechanical Devices:
 - a. Catalog information, mark to identify proposed items and options.
 - b. Descriptive literature.
 - c. External power and signal connections.
 - d. Scaled drawings showing exterior dimensions and locations of electrical and mechanical interfaces.
- 4. Component Data Sheets: Data sheets for I&C components.
 - a. Format and Level of Detail: In accordance with ISA-S20.
 - b. Include component type identification code and tag number on data sheet.
 - c. Specific features and configuration data for each component:
 - 1) Location or service.
 - 2) Manufacturer and complete model number.
 - 3) Size and scale range.
 - 4) Setpoints.
 - 5) Materials of construction.
 - 6) Options included.
 - d. Name, address, and telephone number of manufacturer's local office, representative, distributor, or service facility.
- 5. Sizing and Selection Calculations:
 - a. Primary Elements: Complete calculations plus process data used. Example, for flow elements, minimum and maximum values, permanent head loss, and assumptions made.
 - b. Controlling, Computing and Function Generating Modules: Actual scaling factors with units and how they were computed.

6. Panel Construction Drawings:
 - a. Scale Drawings: Show dimensions and location of panel mounted devices, doors, louvers, and subpanels, internal and external.
 - b. Panel Legend: List front of panel devices by tag numbers, nameplate inscriptions, service legends, and annunciator inscriptions.
 - c. Bill of Materials: List devices mounted within panel that are not listed in panel legend. Include tag number, description, manufacturer, and model number.
 - d. Construction Details: NEMA rating, materials, material thickness, structural stiffeners and brackets, lifting lugs, mounting brackets and tabs, door hinges and latches, and welding and other connection callouts and details.
 - e. Construction Notes: Finishes, wire color schemes, wire ratings, wire and terminal block, numbering and labeling scheme.
7. Panel Control Diagrams: For discrete control and power circuits.
 - a. Diagram Type: Ladder diagrams in format same as shown on Drawings. Include devices, related to discrete functions, that are mounted in or on the panel and that require electrical connections. Show unique rung numbers on left side of each rung.
 - b. Item Identification: Identify each item with attributes listed.
 - 1) Wires: Wire number and color. Cable number if part of multiconductor cable.
 - 2) Terminals: Location (enclosure number, terminal junction box number, or MCP/LAP number), terminal strip number, and terminal block number.
 - 3) Discrete Components:
 - a) Tag number, terminal numbers, and location (“FIELD,” enclosure number, or MCP/LAP number).
 - b) Switching action (open or close on rising or falling process variable), setpoint value and units, and process variable description (for example, Sump Level High).
 - 4) Relay Coils:
 - a) Tag number and its function.
 - b) On right side of run where coil is located, list contact location by ladder number and sheet number. Underline normally closed contacts.
 - 5) Relay Contacts: Coil tag number, function, and coil location (ladder rung number and sheet number).
 - c. Show each circuit individually. No “typical” diagrams or “typical” wire lists will be permitted.
 - d. Ground wires, surge protectors, and connections.
 - e. Circuit Names: Show names corresponding to Circuit and Raceway Schedule for circuits entering and leaving a panel. Refer to Division 26, Electrical.

8. Panel Wiring Diagrams: Show point-to-point and terminal-to-terminal wiring within panel.
9. Panel Plumbing Diagrams: For each panel containing piping and tubing. Show type and size for: Pipes and Tubes: Thickness, pressure rating, and materials.
 - a. Components: Valves, regulators, and filters.
 - b. Connections to panel mounted devices.
 - c. Panel interface connections.
10. Loop Diagrams: Individual wiring diagram for each analog or pulse frequency loop.
 - a. Conform to the minimum requirements of ISA S5.4.
 - b. Under Paragraph 5.3 of ISA S5.4, include the information listed under subparagraphs 2 and 6.
 - c. Drawing Size: Individual 11-inch by 17-inch sheet for each loop.
 - d. Divide each loop diagram into areas for panel face, back-of-panel, and field.
 - e. Show:
 - 1) Terminal numbers, location of dc power supply, and location of common dropping resistors.
 - 2) Switching contacts in analog loops and output contacts of analog devices. Reference specific control diagrams where functions of these contacts are shown.
 - 3) Tabular summary on each diagram:
 - a) Transmitting Instruments: Output capability.
 - b) Receiving Instruments: Input impedance.
 - c) Loop Wiring Impedance: Estimate based on wire sizes and lengths shown.
 - d) Total loop impedance.
 - e) Reserve output capacity.
 - 4) Circuit and raceway schedule names.
11. Interconnecting Wiring Diagrams:
 - a. Diagrams, device designations, and symbols in accordance with NEMA ICS 1.
 - b. Diagrams shall bear electrical Subcontractor's signature attesting diagrams have been coordinated with Division 26, Electrical.
 - c. Show:
 - 1) Electrical connections between equipment, consoles, panels, terminal junction boxes, and field mounted components.
 - 2) Component and panel terminal board identification numbers, and external wire and cable numbers.
 - 3) Circuit names matching Circuit and Raceway Schedule.
 - 4) Intermediate terminations between field elements and panels (for example, to terminal junction boxes and pull boxes).
 - 5) Pull boxes.

12. Installation Details: Include modifications or further details required to adequately define installation of I&C components.
 13. List of spares, expendables, test equipment and tools.
 14. Additional Equipment Recommended: List of, and descriptive literature for, additional spares, expendables, test equipment and tools recommended.
- B. Informational Submittals: For PIC equipment, provide Manufacturer's Certificate of Proper Installation and readiness for operation.
1. Owner Training Plan. Reference Section 01 43 33, Manufacturers' Field Services.
 2. Operation and Maintenance (O&M) Manuals: In accordance with Section 01 78 23, Operation and Maintenance Manuals, unless otherwise specified in this section.
 - a. Content and Format:
 - 1) Complete sets O&M manuals.
 - 2) Sufficient detail to allow operation, removal, installation, adjustment, calibration, maintenance and purchasing replacements for each PIC component.
 - 3) Final versions of Legend and Abbreviation Lists.
 - 4) Manual format in accordance with Section 01 78 23, Operation and Maintenance Manuals.
 - b. Include:
 - 1) Process and Instrumentation Diagrams: One reproducible copy of revised P&ID to reflect as-built PIC design.
 - 2) Refer to paragraph Shop Drawings for the following items:
 - a) Bill of materials.
 - b) Catalog cuts.
 - c) Component data sheets.
 - d) Panel control diagrams.
 - e) Panel wiring diagrams, one reproducible copy.
 - f) Panel plumbing diagrams, one reproducible copy.
 - g) Loop diagrams, one reproducible copy.
 - h) Interconnecting wiring diagrams, one reproducible copy.
 - i) Application software documentation.
 - 3) Device O&M manuals for components, electrical devices, and mechanical devices include:
 - a) Operations procedures.
 - b) Installation requirements and procedures.
 - c) Maintenance requirements and procedures.
 - d) Troubleshooting procedures.
 - e) Calibration procedures.
 - f) Internal schematic and wiring diagrams.

- g) Component Calibration Sheets from field quality control calibrations.
- 4) List of spares, expendables, test equipment and tools provided.
- 5) List of additional spares, expendables, test equipment and tools recommended.
- 3. Performance Acceptance Tests (PAT) Submittals:
 - a. Preliminary Test Procedures: Outlines of proposed tests, forms, and checklists.
 - b. Final Test Procedures: Proposed test procedures, forms, and checklists.
 - c. Test Documentation: Copy of signed off test procedures when tests are completed.

1.05 QUALITY ASSURANCE

- A. Calibration Instruments: Each instrument used for calibrating PIC equipment shall bear the seal of a reputable laboratory certifying that instrument has been calibrated within the previous 12 months to a standard endorsed by the NIST.
- B. Coordination Meetings:
 - 1. In accordance with Section 01 31 19, Project Meetings.
 - 2. Location: Engineer's office.
 - 3. Attended By: Engineer, Owner, and Contractor.
 - 4. Minimum of four are required. Specific dates will be established in progress schedule.
 - 5. First Meeting: Within 36 days after Notice to Proceed.

1.06 DELIVERY, STORAGE, AND HANDLING

- A. Provide Site and warehouse storage facilities for PIC equipment.
- B. Prior to shipment, include corrosive-inhibitive vapor capsules in shipping containers, and related equipment as recommended by the capsule manufacturer.
- C. Prior to installation, store items in dry indoor locations. Provide heating in storage areas for items subject to corrosion under damp conditions.
- D. Cover panels and other elements that are exposed to dusty construction environments.

1.07 ENVIRONMENTAL REQUIREMENTS

- A. Standard Environmental Requirements: Unless otherwise noted, design equipment for continuous operation in these environments:
 - 1. Freestanding Panel and Consoles:
 - a. Inside, Air-conditioned: NEMA 1.
 - b. Inside: NEMA 12.
 - 2. Smaller Panels and Assemblies (that are not Freestanding):
 - a. Inside, Air-conditioned: NEMA 12.
 - b. All Other Locations: NEMA 4X.
 - 3. Field Elements: Outside.

- B. Special Environmental Requirements: Design modification to following panels for continuous operation in environments listed:
 - 1. Main control panels OCS 1 and OCS 2.
 - 2. Local alarm panels LAP-3 and LAP-1.

- C. Environmental Design Requirements: Following defines the types of environments referred to in the above.
 - 1. Inside, Air-conditioned:
 - a. Temperature:
 - 1) Normal: 60 to 80 degrees F.
 - 2) With Up to 4-hour HVAC System Interruptions: 40 to 105 degrees F.
 - b. Relative Humidity:
 - 1) Normal: 10 percent (winter) to 70 percent (summer).
 - 2) With Up to 4-hour HVAC System Interruption: 10 to 100 percent.
 - c. NEC Classification: Nonhazardous.
 - 2. Inside:
 - a. Temperature: 20 to 104 degrees F.
 - b. Relative Humidity: 10 to 100 percent.
 - c. NEC Classification: Nonhazardous.
 - 3. Inside, Corrosive:
 - a. Temperature: Minus 20 to 104 degrees F.
 - b. Relative Humidity: 10 to 100 percent.
 - c. NEC Classification: Nonhazardous.
 - 4. Outside:
 - a. Temperature: Minus 20 to 104 degrees F.
 - b. Relative Humidity: 10 to 100 percent.
 - c. NEC Classification: Nonhazardous.

5. Outside, Corrosive:
 - a. Temperature: Minus 20 to 104 degrees F.
 - b. Relative Humidity: 0 to 100 percent.
 - c. NEC Classification: Nonhazardous.

1.08 SEQUENCING AND SCHEDULING

- A. Activity Completion: The following is a list of key activities and their completion criteria:
 1. Shop Drawings: Reviewed and approved.
 2. Quality Control Submittals: Reviewed and accepted.
 3. Hardware Delivery: Hardware delivered to Site and inventoried by Owner.
 4. PAT: Completed and required test documentation accepted.
- B. PIC Substantial Completion: When Engineer issues Certificate of Substantial Completion.
 1. Prerequisites:
 - a. All PIC submittals have been completed.
 - b. PIC has successfully completed PAT.
 - c. Owner training plan is on schedule.
 - d. All spares, expendables, and test equipment have been delivered to Owner.
- C. PIC Acceptance: When Engineer issues a written notice of final payment and acceptance.
 1. Prerequisites:
 - a. Certificate of Substantial Completion issued for PIC.
 - b. Punch-list items completed.
 - c. Final revisions to O&M manuals accepted.
 - d. Maintenance service agreements for PIC accepted by Owner.
- D. Prerequisite Activities and Lead Times: Do not start the following key Project activities until the prerequisite activities and lead times listed below have been completed and satisfied:

| Activity | Prerequisites and Lead Times |
|--|--|
| Submittal reviews by Engineer | Engineer acceptance of submittal breakdown and schedule |
| Hardware purchasing, fabrication, and assembly | Associated shop drawing submittals completed |
| Shipment | Completion of PIC shop drawing submittals and preliminary O&M manuals |
| Owner training | Owner training plan completed |
| PAT | Startup, Owner training, and PAT procedures completed; notice 4 weeks prior to start |

PART 2 PRODUCTS

2.01 GENERAL

- A. PIC functions as shown on Drawings and as required for each loop. Furnish equipment items as required. Furnish all materials, equipment, and software, necessary to effect required system and loop performance.
- B. First-named Manufacturer: PIC design is based on first-named manufacturers of equipment and materials.
 - 1. If an item is proposed from other than first-named manufacturer, obtain approval from Engineer for such changes in accordance with Article Submittals.
 - 2. If using proposed item requires other changes, provide work and equipment to implement these changes. Changes that may be required include, but are not limited to: different installation, wiring, raceway, enclosures, connections, isolators, intrinsically safe barriers, software, and accessories.
- C. Like Equipment Items:
 - 1. Use products of one manufacturer and of the same series or family of models to achieve standardization for appearance, operation, maintenance, spare parts, and manufacturer's services.
 - 2. Implement all same or similar functions in same or similar manner. For example, control logic, sequence controls, and display layouts.
- D. Components and Materials in Contact with Water for Human Consumption: Comply with the requirements of the Safe Drinking Water Act and other applicable federal, state, and local requirements. Provide certification by manufacturer or an accredited certification organization recognized by the authority having jurisdiction that components and materials comply with the

maximum lead content standard in accordance with NSF/ANSI 61 and NSF/ANSI 372.

1. Use or reuse of components and materials without a traceable certification is prohibited.

2.02 LOOP SPECIFICATIONS

- A. Organization: By unit process and loop number.
- B. Functional Requirements for Control Loops:
 1. Shown on Drawings, in Panel Control Diagrams, and Process and Instrumentation Diagrams (P&ID). P&ID format and symbols are in accordance with ISA S5.1, except as specified or shown on Drawings.
 2. Supplemented by Loop Specifications.
- C. Subheadings for Each Loop:
 1. Functions: Clarifies functional performance of loop, including abstract of complex interlocks.
 - a. Components: Lists major components for each loop. Information listed include: Tag numbers.
 - b. Component Identification Codes: Alphanumeric codes of required components. Refer to Component Specification referenced in Article Supplements.
 - c. Component Names and Options: Required to tailor general Component Specifications to specific application. For example, special materials, mounting, size, unit range, scale, setpoints, and controller options.

2.03 I&C COMPONENTS

- A. Components for Each Loop: Major components for each loop are referenced in Contract Drawings. Furnish all equipment that is necessary to achieve required loop performance.
- B. Component Specifications: Generalized specifications for each type of component are located in their respective Specification sections.

2.04 NAMEPLATES AND TAGS

- A. Panel Nameplates: Enclosure identification located on the enclosure face.
 1. Location and Inscription: As shown.

2. Materials: Laminated plastic attached to panel with stainless steel screws.
 3. Letters: 1/2-inch black on white background, unless otherwise noted.
- B. Component Nameplates—Panel Face: Component identification located on panel face under or near component.
1. Location and Inscription: As shown.
 2. Materials: Laminated plastic attached to panel with stainless steel screws.
 3. Letters: 3/16-inch black on white background, unless otherwise noted.
- C. Component Nameplates—Back of Panel: Component identification located on or near component inside of enclosure.
1. Inscription: Component tag number.
 2. Materials: Adhesive backed, laminated plastic.
 3. Letters: 3/16-inch black on white background, unless otherwise noted.
- D. Legend Plates for Panel-mounted Pushbuttons, Lights, and Switches:
1. Inscription: Refer to:
 - a. Table under paragraph Standard Pushbutton Colors and Inscriptions.
 - b. Table under paragraph Standard Light Colors and Inscriptions.
 - c. P&IDs in Drawings.
 2. Materials: Stainless steel, keyed legend plates. Secured to panel by mounting nut for pushbutton, light, or switch.
 3. Letters: Black on white background.
- E. Service Legends: Component identification nameplate located on face of component.
1. Inscription: As shown.
 2. Materials: Adhesive backed, laminated plastic.
 3. Letters: 3/16-inch black on white background, unless otherwise noted.
- F. Nametags: Component identification for field devices.
1. Inscription: Component tag number.
 2. Materials: 16-gauge, Type 304 stainless steel.
 3. Letters: 3/16-inch imposed.
 4. Mounting: Affix to component with 16- or 18-gauge stainless steel wire or stainless steel screws.

2.05 ELECTRICAL REQUIREMENTS

- A. In accordance with Division 26, Electrical.
- B. I&C and electrical components, terminals, wires, and enclosures: UL-recognized or UL-listed.
- C. Wires within Enclosures:
 - 1. ac Circuits:
 - a. Type: 300-volt, Type MTW stranded copper.
 - b. Size: For current to be carried, but not less than 18 AWG.
 - 2. Analog Signal Circuits:
 - a. Type: 300-volt stranded copper, twisted shielded pairs.
 - b. Size: 18 AWG, minimum.
 - 3. Other dc Circuits.
 - a. Type: 300-volt, Type MTW stranded copper.
 - b. Size: For current carried, but not less than 18 AWG.
 - 4. Special Signal Circuits: Use manufacturer's standard cables.
 - 5. Wire Identification: Numbered and tagged at each termination.
 - a. Wire Tags: Machine printed, heat shrink.
 - b. Manufacturers and Products:
 - 1) Brady; PermaSleeve.
 - 2) Tyco Electronics.
- D. Wires entering or leaving enclosures, terminate and identify as follows:
 - 1. Analog and discrete signal, terminate at numbered terminal blocks.
 - 2. Special signals, terminated using manufacturer's standard connectors.
 - 3. Identify wiring in accordance with Section 26 05 02, Basic Electrical Requirements.
- E. Terminal Blocks for Enclosures:
 - 1. Quantity:
 - a. Accommodate present and spare indicated needs.
 - b. Wire spare PLC I/O points to terminal blocks.
 - c. One wire per terminal for field wires entering enclosures.
 - d. Maximum of two wires per terminal for 18-WG wire for internal enclosure wiring.
 - e. Spare Terminals: 20 percent of all connected terminals, but not less than 10 per terminal block.
 - 2. General:
 - a. Connection Type: Screw compression clamp.
 - b. Compression Clamp:
 - 1) Complies with DIN-VDE 0611.

- 2) Hardened steel clamp with transversal groves that penetrate wire strands providing a vibration-proof connection.
- 3) Guides strands of wire into terminal.
- c. Screws: Hardened steel, captive and self-locking.
- d. Current Bar: Copper or treated brass.
- e. Insulation:
 - 1) Thermoplastic rated for minus 55 to 110 degrees C.
 - 2) Two funneled shaped inputs to facilitate wire entry.
- f. Mounting:
 - 1) Standard DIN rail.
 - 2) Terminal block can be extracted from an assembly without displacing adjacent blocks.
 - 3) End Stops: Minimum of one at each end of rail.
- g. Wire preparation: Stripping only permitted.
- h. Jumpers: Allow jumper installation without loss of space on terminal or rail.
- i. Marking System:
 - 1) Terminal number shown on both sides of terminal block.
 - 2) Allow use of preprinted and field marked tags.
 - 3) Terminal strip numbers shown on end stops.
 - 4) Mark terminal block and terminal strip numbers as shown on Panel Control Diagrams and Loop Diagrams.
 - 5) Fuse Marking for Fused Terminal Blocks: Fuse voltage and amperage rating shown on top of terminal block.
- j. Test Plugs: Soldered connections for 18 AWG wire.
 - 1) Pin Diameter: 0.079 inch.
 - 2) Manufacturer and Product: Phoenix Contact or Rockwell/Allen-Bradley.
- 3. Terminal Block, General-Purpose:
 - a. Rated Voltage: 600V ac.
 - b. Rated Current: 30 amp.
 - c. Wire Size: 22 AWG to 10 AWG.
 - d. Rated Wire Size: 10 AWG.
 - e. Color: Grey body.
 - f. Spacing: 0.25 inch, maximum.
 - g. Test Sockets: One screw test socket 0.079-inch diameter.
 - h. Manufacturer and Product: Phoenix Contact or Rockwell/Allen-Bradley.
- 4. Terminal Block, Ground:
 - a. Wire Size: 22 AWG to 12 AWG.
 - b. Rated Wire Size: 12 AWG.
 - c. Color: Green and yellow body.
 - d. Spacing: 0.25 inch, maximum.
 - e. Grounding: Ground terminal blocks electrically grounded to the mounting rail.

- f. Manufacturer and Product: Phoenix Contact or Rockwell/Allen-Bradley.
- 5. Terminal Block, Blade Disconnect Switch:
 - a. Rated Voltage: 600V ac.
 - b. Rated Current: 10-amp.
 - c. Wire Size: 22 AWG to 12 AWG.
 - d. Rated Wire Size: 12 AWG.
 - e. Color: Grey body, orange switch.
 - f. Spacing: 0.25 inch, maximum.
 - g. Manufacturer and Product: Phoenix Contact or Rockwell/Allen-Bradley.
- 6. Terminal Block, Fused, 24V dc:
 - a. Rated Voltage: 600V dc.
 - b. Rated Current: 16-amp.
 - c. Wire Size: 22 AWG to 10 AWG.
 - d. Rated Wire Size: 10 AWG.
 - e. Color: Grey body.
 - f. Fuse: 0.25 inch by 1.25 inches.
 - g. Indication: LED diode 24V dc.
 - h. Spacing: 0.512 inch, maximum.
 - i. Manufacturer and Product: Phoenix Contact or Rockwell/Allen-Bradley.
- 7. Terminal Block, Fused, 120V ac:
 - a. Rated Voltage: 600V ac.
 - b. Rated Current: 16-amp.
 - c. Wire Size: 22 AWG to 10 AWG.
 - d. Rated Wire Size: 10 AWG.
 - e. Color: Grey body.
 - f. Fuse: 0.25 inch by 1.25 inches.
 - g. Indication: Neon Lamp 110V ac.
 - h. Leakage Current: 1.8 mA, maximum.
 - i. Spacing: 0.512 inch, maximum
 - j. Manufacturer and Product: Phoenix Contact or Rockwell/Allen-Bradley.
- 8. Terminal Block, Fused, 120V ac, High Current:
 - a. Rated Voltage: 600V ac.
 - b. Rated Current: 35 amps.
 - c. Wire Size: 18 AWG to 8 AWG.
 - d. Rated Wire Size: 8 AWG.
 - e. Color: Grey.

- f. Fuse: 13/32 inch by 1.5 inches.
- g. Spacing: 0.95 inch, maximum.
- h. Manufacturer and Product: Phoenix Contact or Rockwell/Allen-Bradley.

F. Grounding of Enclosures:

- 1. Furnish isolated copper grounding bus for signal and shield ground connections.
- 2. Ground bus grounded at a common signal ground point in accordance with National Electrical Code requirements.
- 3. Single-point Ground for Each Analog Loop:
 - a. Locate at dc power supply for loop.
 - b. Use to ground wire shields for loop.
 - c. Group and connect shields as required.
- 4. Ground terminal block rails to ground bus.

G. Analog Signal Isolators: Furnish signal isolation for analog signals that are sent from one enclosure to another. Do not wire in series instruments on different panels, cabinets, or enclosures.

H. Power Distribution within Panels:

- 1. Feeder Circuits:
 - a. One or more 120V ac, 60-Hz feeder circuits as shown on Drawings.
 - b. Make provisions for feeder circuit conduit entry.
 - c. Furnish terminal board for termination of wires.
- 2. Power Panel: Furnish main circuit breaker and a circuit breaker on each individual branch circuit distributed from power panel.
 - a. Locate to provide clear view of and access to breakers when door is open.
 - b. Breaker sizes: Coordinate such that fault in branch circuit will blow only branch breaker but not trip the main breaker.
 - 1) Branch Circuit Breaker: 15 amps at 250V ac.
 - c. Breaker Manufacturers and Products: Refer to Division 26, Electrical.
- 3. Circuit Wiring: P&IDs and Control Diagrams on Drawings show function only. Use following rules for actual circuit wiring:
 - a. Devices on Single Circuit: 20, maximum.
 - b. Multiple Units Performing Parallel Operations: To prevent failure of any single branch circuit from shutting down entire operation, do not group all units on same branch circuit.
 - c. Branch Circuit Loading: 12 amperes continuous, maximum.
 - d. Panel Lighting and Service Outlets: Put on separate 15-amp, 120V ac branch circuit.
 - e. Provide 120V ac plugmold for panel components with line cords.

I. Signal Distribution:

1. Within Panels: 4 mA to 20 mA dc signals may be distributed as 1 to 5V dc.
2. Outside Panels: Isolated 4 mA to 20 mA dc only.
3. All signal wiring twisted in shielded pairs.

J. Signal Switching:

1. Use dry circuit type relays or switches.
2. No interruption of 4 mA to 20 mA loops during switching.
3. Switching Transients in Associated Signal Circuit:
 - a. 4 mA to 20 mA dc Signals: 0.2 mA, maximum.
 - b. 1 to 5V dc Signals: 0.05V, maximum.

K. Relays:

1. General:
 - a. Relay Mounting: Plug-in type socket.
 - b. Relay Enclosure: Furnish dust cover.
 - c. Socket Type: Screw terminal interface with wiring.
 - d. Socket Mounting: Rail.
 - e. Provide holddown clips.
2. Signal Switching Relay:
 - a. Type: Dry circuit.
 - b. Contact Arrangement: 2 Form C contacts.
 - c. Contact Rating: 0 to 5 amps at 28V dc or 120V ac.
 - d. Contact Material: Gold or silver.
 - e. Coil Voltage: As noted or shown.
 - f. Coil Power: 0.9 watts (dc), 1.2VA (ac).
 - g. Expected Mechanical Life: 10,000,000 operations.
 - h. Expected Electrical Life at Rated Load: 100,000 operations.
 - i. Indication Type: Neon or LED indicator lamp.
 - j. Seal Type: Hermetically sealed case.
 - k. Manufacturer and Product: Rockwell/Allen-Bradley.
3. Control Circuit Switching Relay, Nonlatching:
 - a. Type: Compact general-purpose plug-in.
 - b. Contact Arrangement: 3 Form C contacts.
 - c. Contact Rating: 10A at 28V dc or 240V ac.
 - d. Contact Material: Silver cadmium oxide alloy.
 - e. Coil Voltage: As noted or shown.
 - f. Coil Power: 1.8 watts (dc), 2.7VA (ac).
 - g. Expected Mechanical Life: 10,000,000 operations.
 - h. Expected Electrical Life at Rated Load: 100,000 operations.
 - i. Indication Type: Neon or LED indicator lamp.

- j. Push to test button.
- k. Manufacturer and Product: Rockwell/Allen-Bradley.
- 4. Control Circuit Switching Relay, Latching:
 - a. Type: Dual coil mechanical latching relay.
 - b. Contact Arrangement: 2 Form C contacts.
 - c. Contact Rating: 10A at 28V dc or 120V ac.
 - d. Contact Material: Silver cadmium oxide alloy.
 - e. Coil Voltage: As noted or shown.
 - f. Coil Power: 2.7 watts (dc), 5.3VA (ac).
 - g. Expected Mechanical Life: 500,000 operations.
 - h. Expected Electrical Life at Rated Load: 50,000 operations.
 - i. Manufacturer and Product: Rockwell/Allen-Bradley.
- 5. Control Circuit Switching Relay, Time Delay:
 - a. Type: Adjustable time delay relay.
 - b. Contact Arrangement: 2 Form C contacts.
 - c. Contact Rating: 10A at 240V ac.
 - 1) Contact Material: Silver cadmium oxide alloy.
 - d. Coil Voltage: As noted or shown.
 - e. Operating Temperature: Minus 10 to 55 degrees C.
 - f. Repeatability: Plus or minus 2 percent.
 - g. Delay Time Range: Select range such that time delay setpoint fall between 20 to 80 percent of range.
 - h. Time Delay Setpoint: As noted or shown.
 - i. Mode of Operation: As noted or shown.
 - j. Adjustment Type: Integral potentiometer with knob external to dust cover.
 - k. Manufacturer and Products: Potter and Brumfield:
 - 1) Series CB for 0.1 second to 100 minute delay time ranges.
 - 2) Series CK for 0.1 to 120 second delay time ranges.

L. Power Supplies:

- 1. Type: Power supply shall be a redundant output, regulated, DIN rail mount, 24V dc power supply for 4 to 20 mA current loops. Provide one redundant power supply for each panel.
- 2. Required Features:
 - a. Temperature: Operational from -13 to 158 degrees F.
 - b. Output: 24V dc sized as required to meet load demand of connected device(s) plus 25 percent additional capacity.
 - c. Power Requirements: 120V ac, 60 Hz, single phase.
 - d. Ripple: 100 mV peak to peak.
 - e. Protection: Short circuit and over voltage protection.
 - f. Panel Mounting: DIN rail-mounting.
 - g. Redundant configuration with fail output contact to PLC.

3. Model and Manufacturer:
 - a. Compact Power Supply Units with Redundancy Module, Quint Power, as manufactured by Phoenix Contact, Inc.
 - b. "Or equal."

M. Internal Panel Lights for Freestanding Panels:

1. Type: Switched 100-watt incandescent back-of-panel lights.
2. Quantity: One light for every 4 feet of panel width.
3. Mounting: Inside and in the top of back-of-panel area.
4. Protective metal shield for lights.

N. Service Outlets for Freestanding Panels:

1. Type: Three-wire, 120-volt, 15-ampere, GFCI duplex receptacles.
2. Quantity:
 - a. For panels 4 feet wide and smaller: One.
 - b. For panels wider than 4 feet: One for every 4 feet of panel width, two minimum per panel.
3. Mounting: Evenly spaced along back-of-panel area.

O. Internal Panel Lights and Service Outlets for Smaller Panels:

1. Internal Panel Light: Switched 100-watt incandescent light.
2. Service Outlet: Breaker protected 120-volt, 15-amp, GFCI duplex receptacle.
 - a. Required for following panels: As shown on the Typical Power Distribution for Control Panels as shown on Drawings.

P. Standard Pushbutton Colors and Inscriptions: Use following color code and inscriptions for pushbuttons, unless otherwise noted in Contract Drawings.

| Tag Function | Inscription(s) | Color |
|---------------------|-----------------------|-------------------------|
| OO | ON OFF | Black Black |
| OC | OPEN CLOSE | Black Black |
| OCA | OPEN CLOSE AUTO | Black Black Black |
| OOA | ON OFF AUTO | Black Black Black |

| Tag Function | Inscription(s) | Color |
|---------------------|-----------------------|----------------|
| MA | MANUAL AUTO | Black Black |
| SS | START STOP | Black Black |
| RESET | RESET | Black |
| EMERGENCY STOP | EMERGENCY STOP | Red |

1. Lettering Color:
 - a. Black on white and yellow buttons.
 - b. White on black, red, and green buttons.

- Q. Standard Light Colors and Inscriptions: Use following color code and inscriptions for service legends and lens colors for indicating lights, unless otherwise noted in individual Loop Specifications, Article Supplements.

| Tag Function | Inscription(s) | Color |
|---------------------|-----------------------|--------------|
| ON | ON | Red |
| OFF | OFF | Green |
| OPEN | OPEN | Red |
| CLOSED | CLOSED | Green |
| LOW | LOW | Green |
| FAIL | FAIL | Amber |
| HIGH | HIGH | Red |
| AUTO | AUTO | White |
| MANUAL | MANUAL | Yellow |
| LOCAL | LOCAL | White |
| REMOTE | REMOTE | Yellow |

1. Lettering Color:
 - a. Black on white and amber lenses.
 - b. White on red and green lenses.

2.06 MECHANICAL SYSTEMS

A. Flow Element, Rotameter, Purge:

1. For air service, unless otherwise noted.
2. Materials: Glass tube, fiberglass body, stainless steel float, nylon ball check valve.
3. Direct-Reading Scale Length: 2-1/2 inches, minimum.
4. Scale Ranges: 0 to 2.5 scfh for air service or 0 to 10 gph for water service.

5. Integral inlet needle valves.
 6. Integral Differential Pressure Regulators:
 - a. For water service.
 - b. For air service for level ranges greater than 10 feet of water.
 7. Manufacturers and Products:
 - a. Fischer & Porter; Series 10A3130.
 - b. Brooks; Series DS-1350.
- B. Manifold, Three-valve Equalizing:
1. Type: For isolation and equalization of differential pressure transducers.
 2. Materials: Stainless steel.
 3. Manufacturers and Products:
 - a. Anderson, Greenwood and Co.; Type M1.
 - b. Evans.
- C. Pressure Gauge: For other than process variable measurement.
1. Dial Size: Nominal 2-inch dial size.
 2. Accuracy: 2 percent of span.
 3. Scale Range: Such that normal operating pressure lies between 50 and 80 percent of scale range.
 4. Connection: 1/4-inch NPT through bottom, unless otherwise noted.
 5. Manufacturers and Products:
 - a. Ashcroft Utility; Gauge Series 1000.
 - b. Marsh; Standard Gauge Series.
 - c. Ametek U.S.; Gauge Series P500.
 - d. Acculite; Series 2000.
- D. Valve, Needle:
1. Materials: Brass body with 0.020-inch orifice.
 2. Manufacturers and Products:
 - a. Whitey; Model 21RF2.
 - b. Hoke; 3700 Series.
- E. ON/OFF Valves:
1. Type: Ball valve.
 2. Materials: Brass.
 3. Manufacturers and Products:
 - a. Whitey; Series 41 through Series 43.
 - b. Hoke; Flomite 7100 Series.

F. Regulating Valves:

1. Type: Needle valves, with regulating stems and screwed bonnets.
2. Materials: Brass.
3. Manufacturers and Products:
 - a. Whitey; Catalog No. RF or RS.
 - b. Hoke; 3100 through 3300 Series.

G. Valve, Three-way:

1. Type: Ball valve.
2. Materials: Brass with nylon handle.
3. Manufacturers and Products:
 - a. Whitey; Series 41 through Series 43.
 - b. Hoke; Selecto-Mite Series.

H. Valve, Four-way:

1. Type: Four-way, two-position ball valve.
2. Materials:
 - a. Body and Stem: Type 316 stainless steel.
 - b. Handle: Black nylon.
 - c. Packing Gland: Teflon.
3. Ball and stem bed, one-piece assembly.
4. Machined handle stops and directional nameplates.
5. Manufacturers and Products:
 - a. Whitey; Series 457.
 - b. Hoke; Multi-Mite Series.

I. Spool Valve:

1. Type: Five-port arrangement as shown, two-position, push-to-operate knob attached to the spool stem, and spring return.
2. Materials: Aluminum construction with Teflon impregnated aluminum spool, stainless steel spring, and Buna-N O-rings.
3. Port Connection: 1/4-inch OD tube fittings.
4. Manufacturer and Product: Norgren; T71DAOO-TSO-TKO.

J. Solenoid Valve, Two-way:

1. Type: Globe valve directly actuated by solenoid and not requiring minimum pressure differential for operation.
2. Materials:
 - a. Body: Brass globe valves.
 - b. Valve Seat: Buna-N.
3. Size: As noted and normally closed or opened, as noted.
4. Coil: 115V ac, unless noted otherwise.

5. Solenoid Enclosure: NEMA 4.
6. Manufacturer and Product: ASCO; Red Hat Series 8260.

K. Pressure Regulator, Air:

1. Provide air at reduced pressures, as shown, constant to within plus or minus 10 percent for flows from 0 to 300 scfh with 100 psi supply pressure.
2. Setscrew for outlet pressure adjustment.
3. Integral filter and relief valve.
4. Manufacturers and Products:
 - a. Masoneilan; Series 77-4.
 - b. Fisher; Series 67FR.

L. Pressure Regulator, Water:

1. Materials:
 - a. Body: Bronze.
 - b. Spring Case: Cast iron.
 - c. Seat Rings: Brass.
 - d. Valve Disk and Holder: Buna-N and bronze.
 - e. Diaphragm: Buna-N diaphragm.
2. Sizing: For maximum of 7 psi offset pressure.
3. Manufacturers and Products:
 - a. Fisher; Controls Type 95H or 95L.
 - b. Masoneilan; Series 17.

M. Test Tap:

1. Manufacturers and Products:
 - a. Imperial-Eastman; quick-disconnect couplings No. 292-P and caps No. 259-P.
 - b. Crawford Fitting Co.; Swagelok quick-connects Series QC4 and caps QC4-DC.
 - c. Parker; CPI Series precision quick couplings.

N. Copper Tubing and Fittings:

1. Type K hard copper, ASTM B88, with commercially pure wrought copper solder joint fittings. Make joints with 95-5 wire solder, ASTM B32, Grade 95 TA. Do not use cored solder.
2. Alternatively, Type K, soft temper copper tubing, ASTM B88, with brass compression type fittings may be used where shown on the Drawings.

3. Manufacturers:
 - a. Parker-Hannifin.
 - b. Swagelok tube fittings.
- O. Plastic Tubing and Fittings:
1. Tubing: Polyethylene capable of withstanding 190 psig at 175 degrees F.
 - a. Manufacturers and Products:
 - 1) Dekoron; Type P.
 - 2) Imperial Eastman; Poly-Flo black instrument tubing.
 2. Fittings:
 - a. Type: Brass compression.
 - b. Manufacturers and Products:
 - 1) Imperial Eastman; Poly-Flo tube fittings.
 - 2) Dekoron; E-Z fittings.
- P. Stainless Steel Tubing: ASTM A312, Type 316, seamless, soft annealed, as shown on Drawings, 0.065-inch wall.
- Q. Stainless Steel Fittings:
1. Compression Type:
 - a. Materials: Stainless steel, ASTM A182 forged bodies or ASTM A276 barstock bodies, Type 316, flareless.
 - b. Manufacturers and Products:
 - 1) Parker Flodar; BA Series.
 - 2) Swagelok tube fittings.
 - 3) Parker CPI tube fittings; Parker A-LOK dual ferrule tube fittings.
 2. Socket Weld Type:
 - a. Materials: Stainless steel, ASTM A182 forged bodies or ASTM A276 barstock bodies, Type 316 for 3,000 psi maximum working pressure, safety factor 4:1.
 - b. Manufacturers:
 - 1) Cajon.
 - 2) Swagelok.
 - 3) Parker WELDLOK.
- R. Air Set: Consist of a shutoff valve, pressure regulator, discharge pressure gauge, and interconnecting tubing.

S. Purge Set:

1. Parts: Purge rotameter flow element, pressure regulator, pressure gauge, test tap, shutoff valve, spool valve, and interconnecting tubing as shown on Drawings and as specified.
2. Pressure Gauge Scale Range: 150 percent of the process variable.
3. Mounting: Within consoles, panels, or a separate enclosure as shown. For separate enclosure mounted purge sets, refer to paragraphs Nonfreestanding Panel Construction and Factory Finishing for enclosure requirements.

T. Tubing Raceways:

1. Cable tray systems complete with tees, elbows, reducers, and covers.
2. Size in accordance with manufacturer's recommendations for the intended service.
3. Materials: Galvanized steel.
4. Manufacturers:
 - a. Globetray.
 - b. Cope.

U. Air Supply Sets:

1. Parts: Integrally Mounted:
 - a. Pressure Controls: Automatic START/STOP, factory set at 30 psig to 50 psig.
 - b. Valves: Manual drain, manual shutoff, pressure relief, and check valve.
 - c. Pressure gauge.
 - d. Inlet filter muffler.
 - e. Power: 120V ac.
 - f. Compressor: Oil-less, single-cylinder, rated for at least 1 scfm at 50 psig.
 - g. Manufacturers and Products:
 - 1) ITT Pneumotive; GH Series.
 - 2) Gast.
2. Simplex Air Supply Sets:
 - a. Air Receiver: 2 gallons.
 - b. Compressors: One.
3. Duplex Air Supply Sets:
 - a. Air Receiver: 20-gallon.
 - b. Compressors: Two.
 - c. Automatic Failover Control: Factory set at 20 psig.

2.07 SPARE PARTS

| Description | Percent of Each Type and Size Used | No Less Than |
|---------------------------|---|---------------------|
| Annunciator light bulbs | 20 | N/A |
| Annunciator window module | 10 | N/A |
| dc power supplies | 20 | N/A |
| Fuses | 20 | N/A |
| Indicating light bulb | 20 | N/A |
| Relays | 20 | N/A |
| Terminal blocks | 10 | N/A |
| Hand switches | 10 | N/A |

| Component (Code) | Quantity | Option |
|-------------------------|-----------------|--|
| pH sensors | 2 | Range: Application-specific; support pipe, pigtail, plug |

2.08 FABRICATION

A. General:

1. Panels with external dimensions and instruments arrangement as shown on Drawings.
2. Panel Construction and Interior Wiring: In accordance with the National Electrical Code, state and local codes, NEMA, ANSI, UL, and ICECA.
3. Fabricate panels, install instruments, wire, and plumb, at the PIC factory.
4. Electrical Work: In accordance with Division 26, Electrical.

B. Factory Assembly: Assemble panels at the manufacturer's factory. No fabrication other than correction of minor defects or minor transit damage shall be done on panels at Site.

C. UL Listing Mark for Enclosures: Mark stating "Listed Enclosed Industrial Control Panel" in accordance with UL 508A.

D. Wiring Within PIC Panels:

1. Restrain by plastic ties or ducts or metal raceways.
2. Hinge Wiring: Secure at each end so that bending or twisting will be around longitudinal axis of wire. Protect bend area with sleeve.
3. Arrange wiring neatly, cut to proper length, and remove surplus wire.
4. Abrasion protection for wire bundles which pass through holes or across edges of sheet metal.
5. Connections to Screw Type Terminals:
 - a. Locking-fork-tongue or ring-tongue lugs.
 - b. Use manufacturer's recommended tool with required sized anvil to make crimp lug terminations.
 - c. Wires terminated in a crimp lug, maximum of one.
 - d. Lugs installed on a screw terminal, maximum of two.
6. Connections to Compression Clamp Type Terminals:
 - a. Strip, prepare, and install wires in accordance with terminal manufacturer's recommendations.
 - b. Wires installed in a compression screw and clamp, maximum of one for field wires entering enclosure, otherwise maximum of two.
7. Splicing and tapping of wires, allowed only at device terminals or terminal blocks.
8. Terminate 24V dc and analog signal circuits on separate terminal block from ac circuit terminal blocks.
9. Separate analog and dc circuits by at least 6 inches from ac power and control wiring, except at unavoidable crossover points and at device terminations.
10. Arrange wiring to allow access for testing, removal, and maintenance of circuits and components.
11. Plastic Wire Ducts Fill: Do not exceed manufacturer's recommendation.

E. Temperature Control:

1. Freestanding Panels:
 - a. Nonventilated Panels: Size to adequately dissipate heat from equipment mounted inside panel or on panel.
 - b. Ventilated Panels:
 - 1) Furnish with louvers and forced ventilation as required to prevent temperature buildup from equipment mounted inside panel or on panel.
 - 2) For panels with backs against wall, furnish louvers on top and bottom of panel sides.
 - 3) For panels without backs against wall, furnish louvers on top and bottom of panel back.
 - 4) Louver Construction: Stamped sheet metal.

- 5) Ventilation Fans:
 - a) Furnish where required to provide adequate cooling.
 - b) Create positive internal pressure within panel.
 - c) Fan Motor Power: 120V ac, 60-Hz, thermostatically controlled.
 - 6) Air Filters: Washable aluminum, Hoffman Series A-FLT.
2. Refrigerated System: Furnish where heat dissipation cannot be adequately accomplished with natural convection or forced ventilation. Smaller Panels (that are not freestanding): Size to adequately dissipate heat from equipment mounted inside panel or in panel face.
3. Space Heaters: Thermostatically controlled to maintain internal panel temperatures above dew point.

F. Freestanding Panel Construction:

1. Materials: Sheet steel, unless otherwise shown on Drawings with minimum thickness of 10-gauge, unless otherwise noted.
2. Panel Fronts:
 - a. Fabricated from a single piece of sheet steel, unless otherwise shown on Drawings.
 - b. No seams or bolt heads visible when viewed from front.
 - c. Panel Cutouts: Smoothly finished with rounded edges.
 - d. Stiffeners: Steel angle or plate stiffeners or both on back of panel face to prevent panel deflection under instrument loading or operation.
3. Internal Framework:
 - a. Structural steel for instrument support and panel bracing.
 - b. Permit panel lifting without racking or distortion.
4. Lifting rings to allow simple, safe rigging and lifting of panel during installation.
5. Adjacent Panels: Securely bolted together so front faces are parallel.
6. Doors: Full height, fully gasketed access doors where shown on Drawings.
 - a. Latches: Three-point, Southco Type 44.
 - b. Handles: "D" ring, foldable type.
 - c. Hinges: Full length, continuous, piano type, steel hinges with stainless steel pins.
 - d. Rear Access Doors: Extend no further than 24 inches beyond panel when opened to 90-degree position.
 - e. Front and Side Access Doors: As shown on Drawings.

G. Nonfreestanding Panel Construction:

1. Based on environmental design requirements required and referenced in Article Environmental Requirements, provide the following:
 - a. For panels listed as inside, air-conditioned:
 - 1) Enclosure Type: NEMA 12 in accordance with NEMA 250.
 - 2) Materials: Steel.
 - b. For all other panels:
 - 1) Enclosure Type: NEMA 4X in accordance with NEMA 250.
 - 2) Materials: Type 316 stainless steel.
2. Metal Thickness: 14-gauge, minimum.
3. Doors:
 - a. Rubber-gasketed with continuous hinge.
 - b. Stainless steel lockable quick-release clamps.
4. Manufacturers:
 - a. Hoffman Engineering Co.
 - b. Rittal.

H. Factory Finishing:

1. Enclosures:
 - a. Stainless Steel and Aluminum: Not painted.
 - b. Nonmetallic Panels: Not painted.
 - c. Steel Panels:
 - 1) Sand panel and remove mill scale, rust, grease, and oil.
 - 2) Fill imperfections and sand smooth.
 - 3) Paint panel interior and exterior with one coat of epoxy coating metal primer, two finish coats of two-component type epoxy enamel.
 - 4) Sand surfaces lightly between coats.
 - 5) Dry Film Thickness: 3 mils, minimum.
2. Manufacturer's standard finish color, except where specific color is indicated. If manufacturer has no standard color, finish equipment with light gray color.

2.09 ELECTRICAL TRANSIENT PROTECTION

A. General:

1. Function: Protect elements of PIC against damage due to electrical transients induced in interconnecting lines by lightning and nearby electrical systems.

2. Implementation: Provide, install, coordinate, and inspect grounding of surge suppressors at:
 - a. Connection of ac power to PIC equipment including panels, consoles assemblies, and field mounted analog transmitters and receivers.
 - b. At the field and panel, console, or assembly connection of signal circuits that have portions of the circuit extending outside of a protective building.
 3. Construction: First-stage high energy metal oxide varistor and second-stage bipolar silicon avalanche device separated by series impedance. Includes grounding wire, stud, or terminal.
 4. Response: 5 nanoseconds maximum.
 5. Recovery: Automatic.
 6. Temperature Range: Minus 20 to 85 degrees C.
- B. Suppressors on 120V ac Power Supply Connections:
1. Occurrences: Tested and rated for a minimum of 50 occurrences of IEEE 587 Category B test waveform.
 2. First-stage Clamping Voltage: 350 volts or less.
 3. Second-stage Clamping Voltage: 210 volts or less.
 4. Continuous Operation: Power supplies for one four-wire transmitter or receiver: 5 amps minimum at 130V ac. All other applications: 30 amps minimum at 130V ac.
- C. Suppressors on Analog Signal Lines:
1. Test Waveform: Linear 8 microsecond rise in current from 0 amps to a peak current value followed by an exponential decay of current reaching one half the peak value in 20 microseconds.
 2. Surge Rating: Tested and rated for 50 occurrences of 2,000-amp peak test waveform.
 - a. dc Clamping Voltage: 20 to 40 percent above operating voltage for circuit.
 - b. dc Clamping Voltage Tolerance: Less than plus or minus 10 percent.
 - c. Maximum Loop Resistance: 18 ohms per conductor.
- D. Physical Characteristics:
1. Mounted in Enclosures: Encapsulated in flame-retardant epoxy.
 2. For Analog Signals Lines: EDCO PC-642 or SRA-64 series.
 3. For 120V ac Lines: EDCO HSP-121.
 4. Field-mounted at Two-wire Instruments: Encapsulated in stainless steel pipe nipples. EDCO SS64 series.

5. Field-mounted at Four-wire Instruments: With 120V ac outlet, ac circuit breaker, and 10-ohm resistors on signal lines, all in enclosure.
 - a. Enclosure: NEMA 4X fiberglass or Type 316 stainless steel with door.
 - 1) Maximum Size: 12 inches by 12 inches by 8 inches deep.
 - b. Manufacturer and Product: EDCO; SLAC series.
- E. Installation and Grounding of Suppressors: As shown. See surge suppressor installation details. Grounding equipment, installation of grounding equipment, and terminations for field-mounted devices are provided under Division 26, Electrical.

2.10 CORROSION PROTECTION

- A. Corrosion-inhibiting Vapor Capsule Manufacturers:
 1. Northern Instruments; Model Zerust VC.
 2. Hoffmann Engineering Co; Model A-HCI.

2.11 SOURCE QUALITY CONTROL

- A. Scope: Inspect and test entire PIC to ensure it is ready for shipment, installation, and operation.
- B. Location: Manufacturer's factory or Engineer approved staging Site.
- C. Test: Exercise and test all functions.
- D. Temporary PLC software configuring to allow PLC testing.

PART 3 EXECUTION

3.01 EXAMINATION

- A. For equipment not provided by PIC, but that directly interfaces with the PIC, verify the following conditions:
 1. Proper installation.
 2. Calibration and adjustment of positioners and I/P transducers.
 3. Correct control action.
 4. Switch settings and dead bands.
 5. Opening and closing speeds and travel stops.
 6. Input and output signals.

3.02 INSTALLATION

- A. Material and Equipment Installation: Retain a copy of manufacturers' instructions at Site, available for review at all times.
- B. Electrical Wiring: As specified in Division 26, Electrical.
- C. Mechanical Systems:
 - 1. Drawings for PIC Mechanical Systems are diagrammatic and not intended to specifically define element locations or piping and tubing run lengths. Base materials and installations on field measurements.
 - 2. Copper and Stainless Steel Tubing Support: Continuously supported by an aluminum tubing raceway system.
 - 3. Plastic Tubing Supports: Except as shown on Drawings, provide continuous support in conduits or by aluminum tubing raceway system.
 - 4. Install tubing conduit for plastic tubing and tubing raceways parallel with, or at right angles to, structural members of buildings. Make vertical runs straight and plumb.
 - 5. Tubing and Conduit Bends:
 - a. Tool-formed without flattening, and all of same radius.
 - b. Bend Radius: Equal to or larger than conduit and tubing manufacturer's recommended minimum bend radius.
 - c. Slope instrument connection tubing in accordance with installation details.
 - d. Do not run liquid filled instrument tubing immediately over or within a 3-foot plan view clearance of electrical panels, motor starters, or mechanical mounting panel without additional protection. Where tubing must be located in these zones, shield electrical device to prevent water access to electrical equipment.
 - e. Straighten coiled tubing by unrolling on flat surface. Do not pull to straighten.
 - f. Cut tubing square with sharp tubing cutter. Deburr cuts and remove chips. Do not gouge or scratch surface of tubing.
 - g. Blow debris from inside of tubing.
 - h. Make up and install fittings in accordance with manufacturer's recommendations. Verify makeup of tube fittings with manufacturer's inspection gauge.
 - i. Use lubricating compound or TFE tape on stainless steel threads to prevent seizing or galling.
 - j. Run tubing to allow, for example, clear access to doors, controls, and control panels; and to allow for easy removal of equipment.
 - k. Provide separate support for components in tubing runs.
 - l. Supply expansion loops and use adapters at pipe, valve, or component connections for proper orientation of fitting.
 - m. Keep tubing and conduit runs at least 12 inches from hot pipes.

- n. Locate and install tubing raceways in accordance with manufacturer's recommendations. Locate tubing to prevent spillage, overflow, or dirt from above.
 - o. Securely attach tubing raceways to building structural members.
6. Enclosure Lifting Rings: Remove rings following installation and plug holes.

D. Removal or Relocation of Materials and Equipment:

- 1. Remove from Site materials that were part of the existing facility but are no longer used, unless otherwise directed by Engineer to deliver to Owner.
- 2. Repair affected surfaces to conform to type, quality, and finish of surrounding surface.

3.03 FIELD QUALITY CONTROL

A. Startup and Testing Team:

- 1. Thoroughly inspect installation, termination, and adjustment for components and systems.
- 2. Complete onsite tests.
- 3. Complete onsite training.
- 4. Provide startup assistance.

B. Operational Readiness Inspections and Calibrations: Prior to startup, inspect and test to ensure that entire PIC is ready for operation.

- 1. Loop/Component Inspections and Calibrations:
 - a. Check PIC for proper installation, calibration, and adjustment on a loop-by-loop and component-by-component basis.
 - b. Prepare component calibration sheet for each active component (except simple hand switches, lights, gauges, and similar items).
 - 1) Project name.
 - 2) Loop number.
 - 3) Component tag number.
 - 4) Component code number.
 - 5) Manufacturer for elements.
 - 6) Model number/serial number.
 - 7) Summary of functional requirements, for example:
 - a) Indicators and recorders, scale and chart ranges.
 - b) Transmitters/converters, input and output ranges.
 - c) Computing elements' function.
 - d) Controllers, action (direct/reverse) and control modes (PID).

- e) Switching elements, unit range, differential (fixed/adjustable), reset (auto/manual).
 - 8) Calibrations, for example:
 - a) Analog Devices: Actual inputs and outputs at 0, 10, 50, and 100 percent of span, rising and falling.
 - b) Discrete Devices: Actual trip points and reset points.
 - c) Controllers: Mode settings (PID).
 - 9) Space for comments.
 - c. These inspections and calibrations will be spot-checked by Engineer.
2. Leak Test: In accordance with Section 40 80 01, Process Piping Leakage Testing.
- C. Performance Acceptance Tests (PAT):
1. General:
 - a. Test all PIC elements to demonstrate that PIC satisfies all requirements.
 - b. Test Format: Cause and effect.
 - 1) Person conducting test initiates an input (cause).
 - 2) Specific test requirement is satisfied if correct result (effect) occurs.
 - c. Procedures, Forms, and Checklists:
 - 1) Conduct tests in accordance with, and documented on, Engineer accepted procedures, forms, and checklists.
 - 2) Describe each test item to be performed.
 - 3) Have space after each test item description for sign off by appropriate party after satisfactory completion.
 - d. Required Test Documentation: Test procedures, forms, and checklists. All signed by Engineer and Contractor.
 - e. Conducting Tests:
 - 1) Provide special testing materials, equipment, and software.
 - 2) Wherever possible, perform tests using actual process variables, equipment, and data.
 - 3) If it is not practical to test with real process variables, equipment, and data, provide suitable means of simulation.
 - 4) Define simulation techniques in test procedures.
 - f. Coordinate PIC testing with Owner and affected Subcontractors.
 - 1) Excessive Test Witnessing: Refer to Supplementary Conditions.
 2. Test Requirements:
 - a. Once facility has been started up and is operating, perform a witnessed PAT on complete PIC to demonstrate that it is operating as required. Demonstrate each required function on a paragraph-by-paragraph and loop-by-loop basis.

- b. Perform local and manual tests for each loop before proceeding to remote and automatic modes.
- c. Where possible, verify test results using visual confirmation of process equipment and actual process variable. Unless otherwise directed, exercise and observe devices supplied by others, as needed to verify correct signals to and from such devices and to confirm overall system functionality. Test verification by means of disconnecting wires or measuring signal levels is acceptable only where direct operation of plant equipment is not possible.
- d. Make updated versions of documentation required for PAT available to Engineer at Site, both before and during tests.
- e. Make one copy of O&M manuals available to Engineer at the Site both before and during testing.

3.04 MANUFACTURER'S SERVICES

- A. Specialty Equipment: For following equipment, provide the services of a qualified manufacturer's representative during installation, startup, and demonstration testing and Owner training.

3.05 TRAINING

A. General:

- 1. Provide an integrated training program to meet specific needs of Owner's personnel.
- 2. Include training sessions, classroom and field, for managers, engineers, operators, and maintenance personnel.
- 3. Provide instruction on three working shifts as needed to accommodate the Owner's personnel schedule.
- 4. Owner reserves the right to make and reuse video tapes of training sessions.

B. Operations and Maintenance Training:

- 1. Include a review of O&M manuals and survey of spares, expendables, and test equipment.
- 2. Use equipment similar to that provided or currently owned by Owner.
- 3. Provide training suitable for instrument technicians with at least a 2-year associate engineering or technical degree, or equivalent education and experience in electronics or instrumentation.

C. Operations Training:

1. Location: Site.
2. Content: Conduct training on loop-by-loop basis.
 - a. Loop Functions: Understanding of loop functions, including interlocks for each loop.
 - b. Loop Operation: For example, adjusting process variable setpoints, AUTO/MANUAL control transfer, AUTO and MANUAL control, annunciator acknowledgement and resetting.
 - c. Interfaces with other control systems.

D. Maintenance Training:

1. Location: Project Site.
2. Content: Provide training for each type of component and function provided.
 - a. Loop Functions: Understanding details of each loop and how they function.
 - b. Component calibration.
 - c. Adjustments: For example, controller tuning constants, current switch trip points, and similar items.
 - d. Troubleshooting and diagnosis for components.
 - e. Replacing lamps, chart paper, fuses.
 - f. Component removal and replacement.
 - g. Periodic maintenance.

3.06 CLEANING/ADJUSTING

- A. Repair affected surfaces to conform to type, quality, and finish of surrounding surface.
- B. Cleaning:
 1. Prior to closing system using tubing, clear tubing of interior moisture and debris.
 2. Upon completion of Work, remove materials, scraps, and debris from interior and exterior of equipment.

3.07 PROTECTION

- A. Protect enclosures and other equipment containing electrical, instrumentation and control devices, including spare parts, from corrosion through the use of corrosion-inhibiting vapor capsules.
- B. Periodically replace capsules in accordance with capsule manufacturer's recommendations. Replace capsules just prior to Final Payment and Acceptance.

3.08 SUPPLEMENT

- A. The supplement listed below, following “End of Section,” is part of this Specification.
1. Instrument List.
 2. Component Specifications.

END OF SECTION

INSTRUMENT LIST

| Tag Number | Comp Code | Component Title | Options | P&ID | Inst. Detail | Elec | Panel Number |
|-------------------------------|-----------|----------------------------------|---|----------|--------------|----------|------------------------------|
| LE/LIT-225 | L007E | Radar Level Sensor & Transmitter | Range: 0 to 10'-6" Horn type | 03-I-001 | 4091-252 | | |
| LE/LIT-060 | L007E | Radar Level Sensor & Transmitter | Range: 0 to 18'-0" Horn type | 03-I-002 | 4091-252 | | |
| LE/LIT-065 | L007E | Radar Level Sensor & Transmitter | Range: 0 to 18'-0" Horn type | 03-I-002 | 4091-252 | | |
| LE/LIT-070 | L007E | Radar Level Sensor & Transmitter | Range: 0 to 18'-0" Horn type | 03-I-002 | 4091-252 | | |
| LE/LIT-075 | L007E | Radar Level Sensor & Transmitter | Range: 0 to 18'-0" Horn type | 03-I-002 | 4091-252 | | |
| LI-225 LSH-225 LSHH-225 | L10 | Level Indicator-Mechanical Flag | Range 0 to 8'-6" Provide two SPST switches-one for LSH and one for LSHH | 03-I-001 | | 10-E-201 | NFF-PANL-FILL- NaOH/NaOCL |
| LI-060 LSH-060 LSHH-060 | L10 | Level Indicator-Mechanical Flag | Range 0 to 16'-6" Provide two SPST switches-one for LSH and one for LSHH | 03-I-002 | | 20-E-201 | SHF-PANL-FILL HYPO 1 |
| LI-065 LSH-065 LSHH-065 | L10 | Level Indicator-Mechanical Flag | Range 0 to 16'-6" Provide two SPST switches-one for LSH and one for LSHH | 03-I-002 | | 20-E-201 | SHF-PANL-FILL HYPO 1 |

| Tag Number | Comp Code | Component Title | Options | P&ID | Inst. Detail | Elec | Panel Number |
|-------------------------------|-----------|---|---|-----------------|--------------|----------|----------------------|
| LI-070 LSH-070 LSHH-070 | L10 | Level Indicator-Mechanical Flag | Range 0 to 16'-6" Provide two SPST switches-one for LSH and one for LSHH | 03-I-002 | | 20-E-201 | SHF-PANL-FILL HYPO 2 |
| LI-075 LSH-075 LSHH-075 | L10 | Level Indicator-Mechanical Flag | Range 0 to 16'-6" Provide two SPST switches-one for LSH and one for LSHH | 03-I-002 | | 20-E-201 | SHF-PANL-FILL HYPO 2 |
| LI-225 | S12 | Loop powered NEMA 4X Digital Indicator. | Range 0 to 8'-6" | 17-I-1003-I-001 | | 10-E-201 | |
| LI-060 | S12 | Loop powered NEMA 4X Digital Indicator. | Range 0 to 16'-6" | 17-I-1003-I-002 | | 20-E-201 | |
| LI-065 | S12 | Loop powered NEMA 4X Digital Indicator. | Range 0 to 16'-6" | 17-I-1003-I-002 | | 20-E-201 | |
| LI-070 | S12 | Loop powered NEMA 4X Digital Indicator. | Range 0 to 16'-6" | 17-I-1003-I-002 | | 20-E-201 | |
| LI-075 | S12 | Loop powered NEMA 4X Digital Indicator. | Range 0 to 16'-6" | 17-I-1003-I-002 | | 20-E-201 | |

SECTION 40 90 01.01
COMPONENT SPECIFICATIONS

- A. L007E Level Element and Transmitter, Radar, Type E:
1. General:
 - a. Function: Continuous level measurement.
 - b. Type: 26 GHz Radar, noncontacting.
 - c. Loop powered.
 - d. Parts: Element/integral transmitter and accessories as noted.
 2. Service:
 - a. Application: Sodium Hypochlorite.
 - b. Operating Temperature Range:
 - 1) Ambient: Minus 40 degrees F to plus 176 degrees F.
 - 2) At Flange (Inside Vessel):
 - a) Dependent on antenna type and O-ring materials.
 - b) For PTFE rod with PVDF threaded connection, minus 40 degrees F to plus 176 degrees F.
 - 3) Pressure Rating:
 - a) Dependent on antenna type and process temperature.
 - b) For PTFE rod with PVDF threaded connection, minus 14 psig to plus 43.5 psig.
 3. Performance:
 - a. Process Range: As noted.
 - b. Zero Reference: As noted.
 - c. Frequency: C-band.
 - d. Accuracy (maximum measurement error):
 - 1) Up to 10 meters (23 feet), plus or minus 10 mm (0.39 inch).
 - 2) Over 10 meters (23 feet), plus or minus 0.1 percent of measuring range.
 - e. Resolution: 0.04 inch (1mm.).
 - f. Transition Zone (not recommended for measurement): 2 inches from lower end of antenna.
 - g. Medium Suitability:
 - 1) Suitable for most liquids with measuring range decreasing for liquids with smaller dielectric constants.
 - 2) For conductive liquids, (for example, water) maximum possible measuring range is 65 feet.
 4. Element/Integral Transmitter:
 - a. Enclosure:
 - 1) Transmitter: NEMA 4X/IP65 watertight.
 - 2) Antenna: NEMA 6P/IP68.
 - b. Display: Integral, unless otherwise noted.
 - c. Antenna Type: Horn, unless otherwise noted.
 - 1) Available Antenna Types: Horn or rod.

- d. Horn Antenna Parameters:
 - 1) Size: 3 inches, unless otherwise noted.
 - 2) Material: Aluminum, unless otherwise noted.
 - 3) Seal: FKM, Viton, unless otherwise noted.
 - 4) Extension: If noted.
 - a) Material: Type 316L stainless steel, unless otherwise noted.
 - b) Length: 12 inches, unless otherwise noted.
- e. Rod Antenna Parameters:
 - 1) Inactive Length: 4 inches, unless otherwise noted.
 - 2) Inactive Length Material: Flush Mounted PTFE filled sensor, unless otherwise noted.
 - 3) Antistatic or Fully Insulated: Antistatic, unless otherwise noted.
- f. Process Connection:
 - 1) 3-inch ANSI 150-pound flange, unless otherwise noted.
 - 2) Material: Type 316L stainless steel.
- g. Approvals:
 - 1) FM Intrinsic Intrinsically Safe, Class I, Div 1, Group A-D: If noted.
 - 2) FM, Explosion-proof, Class I, Div 1, Group A-D: If noted.
 - 3) Others: As noted.
- h. Element Beam Angle:
 - 1) Antenna size: 3 inches (80mm), flush mount.
 - 2) For 6-, 8-, and 10-inch antennas, beam angles of 23, 19, and 15 degrees, respectively.
 - 3) Rod: 30 degrees.
- 5. Signal and Electrical Interface:
 - a. Analog:
 - 1) 4 mA to 20 mA dc HART.
 - 2) Not furnished when digital interface is noted.
 - b. Digital Interface:
 - 1) FOUNDATION Fieldbus or PROFIBUS PA: If and as noted.
 - c. Conduit Type: 12-inch NPT, unless otherwise noted.
- 6. Other: As noted.
- 7. Accessories:
 - a. Handheld Programmer:
 - 1) One per lot of level units provided: If noted.
 - 2) HART DXR375 Handheld Communicator.
 - b. Software Configuration Package:
 - 1) One per lot of level units provided: If noted.
 - 2) Includes software and HART modem.
 - 3) Software: ToF Tool—Field Tool Package.
 - 4) Modem:
 - a) Commubox FXA191/195.
 - b) USB interface, unless otherwise noted.

- c. Remote Field Signal Indicator: If noted.
 - 1) Signal Interface: 4 mA to 20 mA dc.
 - 2) Enclosure: NEMA 4, IP65.
 - 3) Cable: 65 feet for HART, unless otherwise noted.
 - 4) Mounting Bracket: 1/2-inch pipe mount: If noted.
 - 5) Certification:
 - a) FM Intrinsic Safety, Class I, Div 1, Group A-D: If noted.
 - 6) Model: Remote Display FHX40.
 - d. Others: As noted.
8. Manufacturer and Product: Endress and Hauser Micropilot M FMR 52.
- B. L10 Level Transmitter, Direct Sensing, Flange Mounted:
- 1. General:
 - a. Function: Measure level in a process vessel using mechanical flags.
 - b. Type:
 - 1) Capacitive differential pressure cell.
 - 2) Diaphragm for process fluid isolation.
 - 3) Flange mounting.
 - 4) Smart electronics.
 - 5) Two-wire device.
 - 2. Service:
 - a. Process Liquid: Sodium Hypochlorite.
 - b. Process Temperature Range: Minus 50 degrees F to 100 degrees F, unless otherwise noted.
 - c. Ambient Temperature Range: Minus 40 degrees F to 250 degrees F, unless otherwise noted.
 - d. Humidity: 0 percent to 100 percent relative.
 - 3. Performance:
 - a. Range: As noted.
 - b. Accuracy: Plus or minus 0.75 percent of span.
 - 4. Features:
 - a. Elevation: Provide size required for flange connection between two flanges as shown on the drawings.
 - b. Length shall be as shown on the Mechanical drawings and connect to the two 150-pound flanges on side of tank.
 - c. Type: BP.
 - d. Housing and float Material: Code 2.
 - 1) Flange Size/Type: Class 150, unless otherwise noted to mate up to flange size for each tank as shown on the Process/Mechanical Drawings.
 - 2) Mounting Flange: Stainless steel, unless otherwise noted.
 - 3) Mounting: Flush, unless otherwise noted.
 - 4) Extension Materials (if extension mount noted): Type 316 stainless steel, unless otherwise noted.

5. Signal Output Interface:
 - a. Provide two SPST Normally Open 120V ac rated switches for each to be mounted on the elevations as shown on the Process/Mechanical Drawings for the LSH and LSHH switches.
 6. Enclosure: Polysulfone.
 7. Manufacturers/Model: GEMs Sensors and Controls/SureSite.
- C. S12 Indicator, Field Mount:
1. General:
 - a. Function: Digital indication of analog signal.
 - b. Type:
 - 1) Integral enclosure suitable for field mounting.
 - 2) Loop-powered.
 2. Performance:
 - a. Accuracy: Plus or minus 0.1 percent of full scale plus or minus one count.
 - b. Display Update Rate: 2.5 second minimum.
 - c. Operating Temperature Range: Minus 40 degrees C to 75 degrees C.
 - d. Printed circuit boards conformally coated
 3. Features:
 - a. Display:
 - 1) LCD.
 - 2) 3.5-digits.
 - 3) 1 inch minimum.
 - b. Input Impedance: 75 ohms maximum.
 4. Enclosure:
 - a. NEMA 4X, grey polycarbonate.
 - b. Mounting: Surface, unless otherwise noted.
 5. Loop-powered.
 6. Signal Interface: 4 to 20 mA dc at 24V dc maximum.
 7. Accessories: As required to support the noted options.
 8. Three-year warranty.
 9. Dimensions: 5.67" W x 5.25" H x 4.18" D.
 10. Manufacturers and Products:
 - a. Precision Digital, Natick, MA; Model Vantageview PD6770.

END OF SECTION

SECTION 43 40 02
FIBERGLASS REINFORCED PLASTIC TANK

PART 1 GENERAL

1.01 REFERENCES

- A. The following is a list of standards which may be referenced in this section:
1. American Society of Mechanical Engineers (ASME):
 - a. B16.5, Pipe Flanges and Flanged Fittings: NPS 1/2 through 24.
 - b. RTP-1, Reinforced Thermoset Plastic Corrosion Resistant Equipment.
 2. ASTM International (ASTM):
 - a. D2583, Standard Test Method for Indentation Hardness of Rigid Plastics by Means of a Barcol Impressor.
 - b. D2584, Standard Test Method for Ignition Loss of Cured Reinforced Resins.
 - c. E84, Standard Test Method for Surface Burning Characteristics of Building Materials.
 3. Occupational Safety and Health Act (OSHA): Part 1910.24, Subpart D, Walking-Working Surfaces.

1.02 DEFINITIONS

- A. FRP: Fiberglass reinforced plastic.

1.03 DESIGN REQUIREMENTS

- A. Design Loads: In accordance with Section 01 61 00, Common Product Requirements.
- B. Tanks specified to be fabricated to ASME RTP-1 requirements shall be designed, fabricated, and code stamped. ASME RTP-1 shall be all inclusive for tanks so specified.
- C. The User's Basic Requirements Specification (UBRS) for RTP-1 tanks is part of this specification. The latest version at time of bidding of UBRS shall be completed and submitted by the Contractor.
- D. Design tank, including resin selection (unless specified), wall thickness, methods and locations of support, and stiffener requirements. Design shall be prepared and sealed by designer meeting requirements of Article Quality Assurance.
- E. Each tank shall be designed for 2 inches of water column (w.c.) vacuum.

1.04 SUBMITTALS

A. General:

1. Submit a copy of this specification section, with addendum updates included, and all referenced and applicable sections, with addendum updates included, with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements. If deviations from the specifications are indicated and, therefore requested by the Contractor, the submittal shall be accompanied by a detailed, written justification for each deviation. Failure to include a copy of the marked-up specification sections, along with justification for any requested deviations to the specification requirements, with the submittal shall be cause for rejection of the entire submittal with no further consideration.

B. Action Submittals:

1. Shop Drawings:
 - a. Fabricators catalog information, descriptive literature, specifications, and identification of materials of construction, including complete resin system information.
 - b. Letter from resin manufacturer stating that selected resin is suitable for intended service.
 - c. Detailed fabrication drawings.
 - d. Tank data indicating equipment number, pressure rating, diameter, straight shell lengths, overall lengths, wall thickness, corrosion barrier thickness, and details of nozzle designs.
 - e. Tank capacity chart indicating gallons for each foot of depth and cumulative total from bottom.
 - f. Fabricator's detailed requirements for tank foundations.
 - g. Recommended bolt torque for bolted FRP connections.
 - h. Tank signage and nameplate shop drawings.
2. Samples: Laminate sample representative of production quality of surface finish and visual imperfections.
3. User's Basic Requirements Specification (UBRS).

C. Informational Submittals:

1. Submit tank design calculations and analysis and all other submittals required by ASME RTP-1. Submit design calculations and design drawings for tank anchorage and accessories such as handrails with toeplates, ladders and gates, as shown on the Drawings. Structural calculations and drawings shall be signed and sealed by a Structural Professional Engineer registered in the Commonwealth of Virginia.
2. Certification to ASME RTP-1.

3. Fabricator's Certificate of Compliance with fabrication requirements.
 4. Qualifications of Fabricator's Quality Assurance Supervisor.
 5. Copy of fabricator's Quality Assurance Program.
 6. Quality Assurance Inspection:
 - a. Qualifications of Independent FRP Quality Assurance Inspector.
 - b. Initial QA Inspection Report.
 - c. Certification of Factory Testing.
 7. Certification that supports and access nozzles have been coordinated with actual equipment being furnished.
 8. Special shipping, storage and protection, and handling instructions.
 9. Fabricator's printed installation and tank support instructions.
 10. Manufacturer's Certificate of Proper Installation in accordance with Section 01 43 33, Manufacturers' Field Services.
 11. Manufacturer's warranty information.
 12. Operation and Maintenance Manuals as specified in Section 01 78 23, Operation and Maintenance Manuals.
- D. Contract Closeout Submittals: Service records for repairs performed during construction.

1.05 QUALITY ASSURANCE

- A. Fabricator's Quality Assurance Supervisor: Minimum of 5 years' experience in fabrication of fiberglass structures.
- B. Designer: Registered Structural Professional Engineer in the Commonwealth of Virginia.

1.06 DELIVERY, STORAGE, AND HANDLING

- A. In accordance with Section 01 61 00, Common Product Requirements. In addition, prepare and protect tank for shipment as follows:
 1. Mount tank on padded cradles if shipped horizontally or on a suitable skid if shipped vertically.
 2. Protect flanged nozzles with wooden blinds bolted to flange and having a diameter of 2 inches greater than outside diameter of flange.
 3. Provide either rigid plugs inside ends to prevent deflection or wooden boxes for unflanged components. Brace open end of tank with suitable stiffening member to prevent deflection.
 4. Do not ship components or other pieces loose inside tank.
 5. Load tank with at least 2 inches of clearance between tank (including fittings) and bulkheads, or bed of vehicle.
 6. Regardless of mode of transportation, firmly fasten and pad components to prevent shifting of load or flexing of components while in transit.

1.07 SEQUENCING AND SCHEDULING

- A. Do not ship tank from factory until Engineer's review of Certification of Factory Testing is completed.

1.08 WARRANTY

- A. Provide manufacturer's extended warranty, with Owner named as beneficiary, in writing as specified in the General Conditions.

PART 2 PRODUCTS

2.01 SUPPLEMENTS

- A. Some specific requirements relative to this section are attached as supplements at the end of section.

2.02 SYSTEM DESCRIPTION

- A. Refer to tank schedules at the end of this specification section.

2.03 SERVICE CONDITIONS

- A. Operating Pressure: As Shown on UBRS.

2.04 MATERIALS

- A. Filament-Wound: Fabricate in accordance with ASME RTP-1.
- B. Resin:
 - 1. Suitable for intended service.
 - 2. Premium grade and corrosion resistant, such as chlorendic polyester, vinyl ester, or bisphenol A fumarate polyester, as recommended by manufacturer.
 - 3. Add ultraviolet absorbers to surfacing resin to improve weather resistance.
 - 4. No dyes, pigments, or colorants, except in exterior gel coat.
 - 5. No fillers or thixotropic agents.
 - 6. Curing System:
 - a. As recommended by resin manufacturer or as specified herein.
 - b. Cure products as specified in ASME RTP-1.
 - c. Measure Barcol hardness according to ASTM D2583.
 - 7. Post-cure tank and appurtenances in accordance with resin manufacturer's recommendation for time and temperature. Post-curing should be completed with warm-to-hot dry air, free of combustion products. Hot spots shall be avoided.

8. For hypochlorite service, no MEKP cobalt catalyst system shall be allowed in liner. Cure liner with benzoyl peroxide-dimethyl aniline.
- C. Reinforcements:
1. Surfacing Veil: Chemical surfacing mat, two layers of polyester fabric, 12 mils to 16 mils thick, with a finish and a binder compatible with the lay-up resin.
 2. Other Reinforcements: In accordance with ASME RTP-1.
- D. Laminate:
1. Consists of inner surface (corrosion barrier), interior layer, and exterior layer (structural layer).
 2. Meet visual acceptance criteria in ASME RTP-1.
 3. Meet requirements of mechanical properties in ASME RTP-1.
 4. Reinforce inner surface with resin-rich surfacing veil as specified herein.
 5. Apply a white color coat after inspection of laminate has been completed.
- E. Signage
1. Provide sign on tank with name of tank and tag number.
 - a. Sign shall be mounted on shell of tank.
 - b. Black text, 2-1/2 inches in height.
 - c. White background.
 - d. Material: Heavy duty, long lasting and resistant to sodium hypochlorite, moisture, grease, and oils.
 2. Provide NFPA hazardous chemical signage for Sodium Hypochlorite on each tank.
 - a. Size: 10-inch by 10-inch, minimum.
 - b. Material: Heavy duty, long lasting and resistant to sodium hypochlorite, moisture, grease, and oils.
 - c. Sign shall be mounted on shell of tank above tank name and tag number signage.
 3. Locate tank signage so signs are clearly visible from ground floor of buildings. Engineer to review and approve final signage locations.
- F. Nameplate:
1. Identify each tank with fabricator's name, capacity in gallons, tank dimensions (diameter and straight shell height), maximum temperature, design pressure/vacuum, specific gravity, pH, resin, minimum thickness, tank number, tank name, and date of manufacture.
 2. Provide permanent marking. Seal decals, labels, etc., into laminate exterior with clear resin.

G. Nozzles:

1. Gusset 4-inch or smaller nozzles with conical or plate type gussets. Larger nozzles shall be gusseted, if noted.
2. Finish flush with inside surface of tank, unless otherwise indicated.
3. Gaskets:
 - a. Provide two per nozzle, 1/8-inch-thick, full-face elastomeric material having a hardness of Shore A60 plus or minus 5.
 - b. Material shall be suitable for intended service.
4. Flanged Nozzles: Rated at 100 psi, with other dimensions and bolting corresponding to ASME B16.5 for 150-pound steel flanges.
5. Back face of flanges shall be spot-faced, flat and parallel to flange face of sufficient diameter to accept SAE metal washer under bolthead or nut.

H. Dip-Pipes:

1. Provide double-flanged nozzle for all internal dip pipes as shown on drawings.
2. Provide inside and outside surfaces of dip-pipes with corrosion barrier.
3. Surfacing veil for this corrosion barrier shall be same as specified for tank.
4. Corrosion barrier shall consist of appropriate surfacing veil, backed by two layers of fiberglass mat.
5. If "ready-made" pipe is used, it shall have an equivalent internal corrosion barrier and shall have specified corrosion barrier applied to outside surface.

2.05 APPURTENANCES

A. Supports:

1. Pipe Supports:
 - a. Provide pipe supports from tank for all pipes within 12 inches of exterior tank wall and 2 feet above floor or tank pad. Tank supports shall be FRP, integral to tank design and designed by tank manufacturer.
 - b. Spacing of supports shall be as recommended by fabricator but shall not be greater than 4 feet on center.
 - c. Tank vendor to locate and integrally install FRP tank support.
 - d. FRP complete with necessary bolts, nuts, and washers.

B. Ladders, Handrails, and Elevated Walkway Attached to Tanks: See Section 06 82 00, Glass-Fiber-Reinforced Plastic.

1. Provide ladder safety system for ladders as required and as specified in Section 05 50 00, Metal Fabrications.

2. Comply with OSHA standards.
- C. Lifting Lugs: Provide suitably attached for tank weighing over 100 pounds.
- D. Anchor Bolts: Hastelloy C or Grade 2 titanium steel adhesive anchors, sized by fabricator and as specified in Section 05 05 19, Post-Installed Anchors. Where existing concrete support pads are re-used for new tanks, new anchor bolt locations shall be offset as necessary from existing anchor bolts.
- E. Manway: Provide side access manway with hinge.
 1. Manway Bolts: Titanium bolts and nuts as specified in Section 05 50 00, Metal Fabrications.

2.06 SOURCE QUALITY CONTROL

- A. Perform quality control inspections as required per ASME RTP-1.
- B. Identify and retain cutouts. Engineer may select certain cutouts for testing for physical properties of laminate.
- C. Factory Test Reports:
 1. Certify results, by signature, of the following:
 - a. Inspections.
 - b. Results of hydrostatic testing.
 - c. Test reports of physical properties of standard laminates.

2.07 MANUFACTURERS

- A. Tanks shall be provided by the manufacturers listed below.
 1. Augusta Fiberglass, Blackville, SC.
 2. Fiber Glass Systems LP, Belton, TX.
 3. Plas-Tanks Industries, Inc., Hamilton, OH.
 4. RL Industries, Inc., Fairfield, OH.

PART 3 EXECUTION

3.01 INSTALLATION

- A. In accordance with fabricator's written instructions.
- B. Accurately place anchor bolts using templates furnished by fabricator, and as specified in Section 05 50 00, Metal Fabrications.

3.02 FIELD QUALITY CONTROL

A. Functional Test:

1. Conduct on each tank.
2. Hydrostatic leak test with tank full of clean water. Allow water to stand for 24 hours to verify no leakage.
 - a. Coordinate level element calibrating as part of tank hydrostatic testing.

3.03 MANUFACTURER'S FIELD SERVICES

- #### A. Provide fabricator's representative at Site in accordance with Section 01 43 33, Manufacturers' Field Services, and Section 01 91 14, Equipment Testing and Facility Startup, for installation assistance, inspection and certification of proper installation and startup assistance for specified component, subsystem, equipment, or system.

3.04 SUPPLEMENTS

- #### A. The supplements listed below, following "End of Section," are part of this specification.
1. FRP Tank Schedule 1.
 2. FRP Tank Schedule 2.
 3. UBRS Form.

END OF SECTION

| FRP Tank Schedule 1 | | | |
|---|-------------------------|-------------------------|-------------------------|
| Name of Tank* | NFF-TANK-HYPO | SHF-TANK-HYPO-01 | SHF-TANK-HYPO-02 |
| Filament-wound or Contact-molded | Filament Wound | Filament Wound | Filament Wound |
| Nominal Maximum Capacity Measured to High Solution Level (gallons, each tank) | 6,680 | 17,130 | 17,130 |
| Installation (Vertical/Horizontal) | Vertical | Vertical | Vertical |
| Diameter (feet) | 11 | 13 | 13 |
| Straight Shell Height | 10 | 18 | 18 |
| Support (saddles, flat pad, legs) | Flat pad | Flat pad | Flat pad |
| Type of Bottom Head | Flat | Flat | Flat |
| Type of Top Head | Domed | Domed | Domed |
| Ladder Required (Yes/No), Material | Yes, FRP | Yes, FRP | Yes, FRP |
| Dome Top Handrail and Toe board Required, (Yes/No), Materials | Yes, FRP | Yes, FRP | Yes, FRP |
| Tank Location (indoor/outdoor) | Indoor | Indoor | Indoor |
| Ambient Temperature Range (degrees F) | 0-100 | 0-100 | 0-100 |
| Exterior Loading (psf): | | | |
| Personnel Roof Loads | 100 psf | 100 psf | 100 psf |
| Platforms | N/A | N/A | N/A |
| Mixers | N/A | N/A | N/A |
| Pipe Supports | Yes, inside and outside | Yes, inside and outside | Yes, inside and outside |
| Operating Contents: | | | |
| Temperature (degrees F, not to exceed 180) | Ambient | Ambient | Ambient |
| Chemical Composition | Sodium Hypochlorite | Sodium Hypochlorite | Sodium Hypochlorite |
| Specific Gravity | 1.20 | 1.20 | 1.20 |
| Concentration | 5 to 15% | 5 to 15% | 5 to 15% |
| pH Range | 11 | 11 | 11 |
| Insulation/Heat Tracing (Yes/No) | No | No | No |
| Calibration Strip | No | No | No |

| FRP Tank Schedule 2 | | |
|---|-------------------------|-------------------------|
| Name of Tank* | SHF-TANK-HYPO-03 | SHF-TANK-HYPO-04 |
| Filament-wound or Contact-molded | Filament Wound | Filament Wound |
| Nominal Maximum Capacity Measured to High Solution Level (gallons, each tank) | 17,130 | 17,130 |
| Installation (Vertical/Horizontal) | Vertical | Vertical |
| Diameter (feet) | 13 | 13 |
| Straight Shell Height | 18 | 18 |
| Support (saddles, flat pad, legs) | Flat pad | Flat pad |
| Type of Bottom Head | Flat | Flat |
| Type of Top Head | Domed | Domed |
| Ladder Required (Yes/No), Material | Yes, FRP | Yes, FRP |
| Dome Top Handrail and Toe board Required, (Yes/No), Materials | Yes, FRP | Yes, FRP |
| Tank Location (indoor/outdoor) | Indoor | Indoor |
| Ambient Temperature Range (degrees F) | 0-100 | 0-100 |
| Exterior Loading (psf): | | |
| Personnel Roof Loads | 100 psf | 100 psf |
| Platforms | N/A | N/A |
| Mixers | N/A | N/A |
| Pipe Supports | Yes, inside and outside | Yes, inside and outside |
| Operating Contents: | | |
| Temperature (degrees F, not to exceed 180) | Ambient | Ambient |
| Chemical Composition | Sodium Hypochlorite | Sodium Hypochlorite |
| Specific Gravity | 1.20 | 1.20 |
| Concentration | 5 to 15% | 5 to 15% |
| pH Range | 11 | 11 |
| Insulation/Heat Tracing (Yes/No) | No | No |
| Calibration Strip | No | No |

**USER'S BASIC REQUIREMENTS SPECIFICATION (UBRS)
As Required by the Provisions of ASME RTP-1**

RTP Edition No. _____

UBRS Revision No. _____

User Firm Name: _____

User's Agent Firm Name: _____

Title of Equipment: _____

User's Designation No.: _____

Installation Location (Name and Address):

UBRS Prepared by (User or User's Agent):

Name: _____ Phone No.: _____ Date: _____

Address: _____

1. Equipment Description (equipment sketch and nozzle schedule must be attached):

2. Additional Fabricator Responsibilities:

Special Requirements:

Acoustic Emission Testing

Inspection or Testing Requirements not Listed in the Standard _____

User Waives Visual Inspection Prior to Application of Final Exterior Coat:

Yes No

Visual Inspection Acceptance Level (refer to Table 6-1 of ASME RTP-1):

Level 1

Level 2

Quantity Limitations for Gaseous Air Bubbles or Blisters: _____

Additional Inspection Aids/Methods (refer to Para. 6-940(c) of ASME RTP-1):

3. Material Selection:

3.1 Material Selection by:

Resin Manufacturer (include data per Section 4 of this Document)

Fabricator (include data per Section 4 of this Document)

End User. Applicable User's Specifications/Standards, Codes, Ordinances, FDA Requirements, etc. (list and specify; attach copies of local code/ordinance requirements): _____

Other _____

3.2 Material of Construction: See Section 43 40 02, Fiberglass Reinforced Plastic Tanks

Resin: _____ Catalyst/Cure System: _____

Veil: _____ Barcol Hardness per Para. 6-910(b)(4): _____

Lift Lugs: RTP Carbon Steel Other: _____

Hold-down Lugs: RTP Carbon Steel Other: _____

4. Chemical Service Data (must be provided when Fabricator or resin manufacturer is making material selection): _____

4.1 Description of Process Function and Process Sequence: _____

4.2 Contents:

| | <u>Concentration</u> | | |
|----------------------|----------------------|---------------|----------------------|
| <u>Chemical Name</u> | <u>Max. %</u> | <u>Min. %</u> | <u>Exposure Time</u> |
| _____ | _____ | _____ | _____ |
| _____ | _____ | _____ | _____ |
| _____ | _____ | _____ | _____ |
| _____ | _____ | _____ | _____ |

4.3 pH Range: ___ Max. ___ Min.

5. Design:

5.1 Design Conditions:

| | <u>Operating</u> | <u>Design</u> |
|-------------------|------------------|---------------|
| Internal Pressure | _____ | _____ |
| External Pressure | _____ | _____ |
| Temperature | _____ | _____ |
| Specific Gravity | _____ | _____ |
| Liquid Level | _____ | _____ |

Wind/Seismic/Snow Code (include edition or year) _____

Ultimate Design Wind Speed: _____

Nominal Design Wind Speed:

Risk Category

Exposure Category: _____

Elevation Above Grade _____ ft Topographic Factors: _____

Site Class: _____

Site-specific Seismic Information (ground motion coefficients, etc.)

Ground Snow Load: _____

Capacities: Operating _____ gal

 Flooded _____ gal

5.2 Mechanical Agitator: Required Not Required

Dead Load _____ lb

Static Bending Moment _____ ft-lb

Dynamic Bending Moment _____ ft-lb

Torque _____ ft-lb

Horsepower _____ hp

Impeller Speed _____ rpm

Impeller Diameter _____ in

Number of Impellers _____

Foot Bearing: Yes No

5.3 Heating and Cooling:

Electric Panels

Steam Coil

Steam Sparger

Heat Exchanger

Other _____

5.4 Mechanical and Other Forces:

Violent Chemical Reaction

Subsurface Introduction of Gas and Vapor

Subsurface Introduction of Steam

Transmitted Mechanical Load/Force

Impact Due to Introduction of Solids

Vacuum from Pump Down (or Vessel Draining)

Vacuum from Cool Down

Other _____

5.5 Corrosion Barrier Excluded from Structural Calculations:

Yes

No

5.6 Declaration of Critical Service (only by User or User's Agent; refer to Para. 1-210 of ASME RTP-1):

Yes

No

6. Designation of Inspection (Reviewer Paras. 1-400, 1-430, and 1-440 of ASME RTP-1. It must be recognized that ASME RTP-1 establishes numerous duties for the Inspector, which necessitates that the Inspector be present in the fabrication shop throughout a major portion of the fabrication interval.) Inspector shall be:

Fabricator's Quality Control Principal

User's Representative

Other _____

Inspector's Name: _____ Telephone: _____

Company: _____

Address: _____

6.1 Approval of Inspector Designation:

6.1.1 Authorized User's Representative:

Name _____ Title _____

Signature _____ Date _____

6.1.2 Authorized Fabricator's Representative:

Name _____ Title _____

Signature _____ Date _____

Additional Requirements: _____

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**DRAWINGS
(BOUND SEPARATELY)**
