CONTRACT PROVISIONS AND PLANS

FOR THE CONSTRUCTION OF:

Salmon Creek Treatment Plant Dewatering Equipment Replacement

VOLUME II – SPECIFICATIONS

SCTP Dewatering Equipment Replacement Project No. 93-2021-0058

A Discovery Clean Water Alliance Capital Project with Clark Regional Wastewater District as Administrative Lead

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January 2026

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CONTRACT PROVISIONS AND PLANS

Salmon Creek Treatment Plant
Dewatering Equipment Replacement

VOLUME II – SPECIFICATIONS

SCTP Dewatering Equipment Replacement Project No. 93-2021-0058

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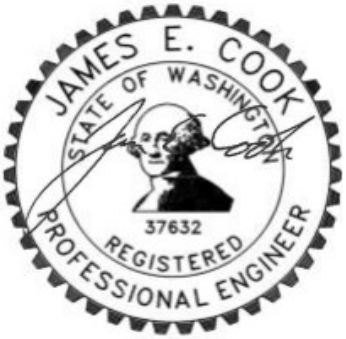
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SECTION 02 41 00

DEMOLITION

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes:
   1. Demolition and removal of buildings or structures.
   2. Demolition and removal of exposed piping and appurtenances.
   3. Demolition and removal of buried piping.

1.02 DEFINITIONS

A. Remove: Detach items from existing construction and legally dispose of them off-site unless indicated to be removed and salvaged or removed and reinstalled.

B. Remove and Salvage: Carefully detach from existing construction, in a manner to prevent damage, and deliver to Owner.

C. Remove and Reinstall: Detach items from existing construction, prepare for reuse, and reinstall where indicated.

D. Existing to Remain: Existing items of construction that are not to be permanently removed and that are not otherwise indicated to be removed, removed and salvaged, or removed and reinstalled.

E. Abandon-In-Place: Render item permanently nonoperational in its existing location, detach from any existing construction and cease to maintain.

1.03 PRE-DEMOLITION MEETINGS

A. Pre-demolition Conference: Conduct conference at Project site.
   1. Inspect and discuss condition of construction to be demolished.
   2. Review structural load limitations of existing structure.
   3. Review and finalize demolition schedule and verify availability of materials, demolition personnel, equipment, and facilities needed to make progress and avoid delays.
   4. Review requirements of work performed by other trades that rely on substrates exposed by demolition operations.
   5. Review areas where existing construction is to remain and requires protection.

1.04 SUBMITTALS

A. Proposed Protection Measures: Submit report, including drawings, that indicates the measures proposed for protecting individuals and property, for environmental protection, for dust control and for noise control. Indicate proposed locations and construction of barriers.

B. Schedule of Demolition Activities: Schedule the following activities in conjunction with the requirements of Section 01 12 16:

1. Detailed sequence of demolition and removal work, with starting and ending dates for each activity. Ensure Owner's on-site operations are uninterrupted.
2. Interruption of utility services. Indicate how long utility services will be interrupted.
3. Coordination for shutoff, capping, and continuation of utility services.

C. Coordination of Owner's continuing occupancy of portions of existing building and of Owner's partial occupancy of completed Work.

Inventory: Submit a list of items to be removed and salvaged and deliver to Owner prior to start of demolition.

D. Pre-demolition Photographs or Video: Submit before Work begins.

1.05 CLOSEOUT SUBMITTALS

A. Inventory: Submit a list of items that have been removed and salvaged and items that have been removed and disposed.

B. Landfill Records: Indicate receipt and acceptance of hazardous wastes by a landfill facility licensed to accept hazardous wastes.

PART 2 PRODUCTS

2.01 GENERAL

A. Provide all materials and equipment in suitable and adequate quantity as required to accomplish the demolition work shown, specified herein, and as required to complete the Project.

PART 3 EXECUTION

3.01 GENERAL

A. Major obstructions encountered that are not shown or indicated on the Drawings, or could not have been foreseen by visual inspection of the site prior to bidding, should immediately be brought to the attention of the Owner. Owner will make a determination for proceeding with the work.

3.02 SAFETY REQUIREMENTS

A. All debris, materials, piping, and miscellaneous waste products from the demolition process shall be removed safely from the project site as soon as possible. Dispose of in accordance with applicable federal, state and local regulations. Contractor is responsible for determining these regulations and shall bear all costs associated with disposal of these items.

B. Hazardous Materials:
   1. Existing facilities, or portions thereof, to be demolished may contain hazardous materials such as:
      a. Residual chemicals in existing or abandoned piping.
      b. Or other unknown hazardous materials.
   2. Take all necessary precautions when handling these materials. Protect work area at all times until hazardous materials are stored in specially treated containers and the area has been cleaned.
   3. Remove and dispose of hazardous materials in accordance with federal, state and local regulations.
   4. Obtain all permits necessary to perform demolition work on hazardous materials.

3.03 UTILITIES

A. Determine whether there are utilities in demolition areas that are needed for continued service to other facilities. Relocate such utilities before demolition work begins.

B. Provide temporary services during interruptions to existing utilities as acceptable to Owner and owner of utilities.

C. Utilities serving facilities to be demolished shall be isolated as shown on the Drawings or as may be directed by the Owner. Isolation shall occur at a point closest to the remaining active portion of the utility.

D. Remove utility lines that are exposed by demolition excavation. Likewise, remove all manholes, catch basins, and vault type structures no longer in use.

E. Plug gravity lines with concrete to prevent groundwater infiltration. Interior of pipe shall be cleaned and then completely filled with concrete for a length of at least three pipe diameters from the ends.

3.04 DEMOLITION

A. The demolition drawings are based on available information, but the structures may differ from what is presented. The Contractor shall be responsible for determining the scope and extent of the required work by inspecting the site prior to submittal of bid. Additional record drawings are available from the Owner.

B. Equipment and materials, including piping within the limits of demolition, unless otherwise specified, will become the property of the Contractor.

C. Drawings define minimum portion of facilities and structures to be removed. Unless otherwise shown, clean saw cuts shall be made to limits of demolition shown. If cuts or breaks are made exceeding limits shown, repair the cuts or breaks back to the dimensions shown on Drawings at the Contractor's expense. Submit repair procedures for Owner's review. Provide saw cut at all pavement surface and curb removal limits and where neat connection lines are required.

D. Protect structures and equipment from damage during demolition work. No equipment shall be removed without the written approval of the Owner.

E. Remove piping from areas to be backfilled. Piping to be abandoned in place shall be capped with a watertight plug at demolished end in a manner that will prevent entrance of soil, groundwater or moisture. Restrained caps or plugs shall be installed at demolished ends for pressurized services and where shown on the Drawings.

F. Only equipment specified herein, shown on the Drawings, designated by the Owner in the field for removal, or approved by the Owner during construction shall be removed. Contractor shall be responsible for the sequence of equipment removal and shall remove it with minimal damage. The limits of removal of equipment shall be as specified on the Drawings or as directed by the Owner. Equipment removal shall include removal of such items as equipment, piping and accessories, supports, piping and tubing supports, fasteners, anchor bolts, and other items. Removal of equipment shall include removal of conduits and wiring from equipment back to nearest junction box. Removal of equipment shall include removal of concrete pads that support equipment, piping and other accessories.

G. All other areas of the plant not within the limits of demolition work shown on the Demolition Photograph, Drawings or as specified herein shall be left undisturbed. Any damage to these areas during the demolition process shall be repaired or replaced to original pre-contract conditions at the Contractor's expense.

H. In areas where concrete portions are to be removed from a structure, the edge of removal shall be cut with a concrete saw to leave a perpendicular edge or core drilled when required removal is circular in shape. All reinforcing shall be cut and removed unless otherwise shown or instructed. Cracked or damaged concrete shall be removed to solid concrete. Spalled edges may be required to be re-sawn at the discretion of the Owner.

I. Cut off concealed or embedded conduit, boxes, anchor bolts, or other materials a minimum of 1 inch below final finished surface. Where necessary, empty conduits shall be plugged with fireproof sealant to maintain fire rating for wall. For existing circuits no longer needed, remove conductors from the conduit. Remove all surface-mounted conduit that is no longer needed. For conduit below grade or concealed within wall, cap and abandon conduit in place. For existing circuits to remain operational, intercept existing conduit at the most convenient location or as shown and splice and extend conduit to new location. Install new conductors where required to accomplish indicated results. New conductors shall be continuous without splices between J-boxes.

3.05 PARTIAL DEMOLITION

A. Remove all facilities that are scheduled for demolition to their full depth, including foundation slabs and footings, unless otherwise shown or specified for partial demolition.

B. Partial demolition includes those facilities where a portion of a structure is to remain. Partial demolition also includes the removal and disposal of all pipe, pipe hangers, mechanical equipment, equipment supports, structural attachments and supports, and embedded items from below grade portion of facilities that will be left in place and backfilled. Limits of partial demolition are shown on the Drawings.

C. Partial demolition procedures shall not impair the integrity of the existing structure that is to remain. Where necessary, and where shown, the Contractor shall saw cut or line core drill the existing structure to prevent rupturing or cracking facilities that remain in use. Those structures damaged by the Contractor that are to remain in service shall be repaired to the satisfaction of the Owner at the Contractor's expense.

D. Cut off all pipes, structural attachments, and embedded metal supports that project into the demolition area flush with the wall, floor or ceiling.

E. Remove all pipe hangers, mechanical equipment, mechanical attachments, and supports. Where necessary, empty pipes shall be plugged with fireproof sealant to maintain fire rating for wall.

F. Unless otherwise noted on the drawings where concrete removal occurs, existing reinforcing that is exposed shall be burned off at least 1 inch into the remaining concrete. All holes shall be patched with epoxy concrete to form a smooth wall or floor finish.

3.06 MISCELLANEOUS DEMOLITION

A. All existing pavement, landscaping, and other surface features demolished because of the Contractor's activities shall be replaced back to its original condition unless other restoration work is called for on the Drawings.

3.07 PROTECTION

A. The Contractor shall provide protection devices including barricades, fencing, warning signs, lights, and whatever else is necessary to ensure the security of, and within, the facility during all phases of demolition. Requirements of federal, state and local statutes and regulations dealing with demolition or public safety shall be strictly adhered to by the Contractor.

3.08 DISPOSAL OF DEMOLITION DEBRIS

A. Remove demolition debris from the work site and dispose in accordance with all local laws, codes and ordinances at the Contractor's expense.

3.09 EQUIPMENT TO BE SALVAGED OR RELOCATED

A. Do not remove equipment and materials without approval of the Owner.

B. For equipment designated to be demolished in the dewatering building, the Owner reserves the right to designate any equipment for salvage and delivery to the Owner prior to the commencement of demolition. At minimum, "delivery" shall include placement of the salvaged equipment anywhere on the plant site as required by the Owner. The following items are designated for salvage, at minimum:
   1. Wash water pumps.
   2. Conveyor motors and gearboxes.
   3. Conveyor gates and actuators.
   4. PLC equipment, including processors, HMIs, and I/O cards.
   5. Temporary cake conveyor (78M4499).

C. Salvaged equipment shall not be damaged during removal. Any damaged equipment shall be repaired by the Contractor to the satisfaction of the Owner or replaced at the Contractor's expense.

D. Properly store and maintain equipment and materials in same condition as when removed, until delivery to the Owner.

E. Owner will determine condition of equipment and materials prior to removal.

3.10 PHOTOGRAPHS AND VIDEOS

A. Prior to the removal of existing construction, create photographs or videos of the existing construction to be removed to provide documentation of this facility and its surroundings. These photographs and/or videos shall be submitted to the Owner during the pre-demolition meetings described herein.

END OF SECTION

SECTION 03 11 00

CONCRETE FORMING

PART 1 GENERAL

1.01 DESCRIPTION

A. Formwork requirements for concrete construction.

1.02 QUALITY ASSURANCE

A. References:

1. The references listed below are part of this section. Where a referenced document cites other standards, such standards are included as references under this section as if referenced directly. In the event of conflict, the requirements of this section shall prevail.

Reference	Title
ACI 117	Tolerances for Concrete Construction and Materials
ACI 301	Specifications for Structural Concrete
ACI 318	Building Code Requirements for Structural Concrete
DOC/NIST PS 1	Voluntary Product Standard, Structural Plywood

B. Design – General:

1. Provide design of formwork, shoring and reshoring systems by the Contractor's Professional Engineer currently registered in the State of Washington.
2. Design, engineering, and construction of formwork, shoring, and reshoring systems is the responsibility of the Contractor.
3. Develop a procedure and schedule for removal of shores (and installation of reshores).
4. Structural record calculations, signed and sealed by the Contractor's Engineer, are required to prove that all portions of the structure, in combination with the remaining forming and shoring systems, have sufficient strength to safely support their own weight plus the loads placed thereon.
5. When developing procedures, schedules, and structural calculations; consider the structural system that exists, effects of imposed loads, and the strength of concrete at each stage of construction.

C. Design Criteria:

1. Design formwork in accordance with ACI 301 and ACI 318 for building structures and ACI 350 and 350.5 for environmental structures to provide concrete finishes as specified in Section 03 30 00.
2. Design systems for full height of wet concrete pressure.
3. Design formwork to limit maximum deflection of form facing materials, as reflected in concrete surfaces exposed to view, to 1/240 of span.

1.03 SUBMITTALS

A. Action Submittals:
   1. Procedures: Section 01 33 00.
   2. Manufacturer's product data with installation instructions:
      a. Form materials.
      b. Form ties (with waterstops).
      c. Form release compound.
      d. Void forms.

B. Informational Submittals:
   1. Procedures: Section 01 33 00.
   2. Letter of certification:
      a. Stating that formwork has been designed in accordance with this specification and referenced documents, sealed and stamped by the Contractor's registered design Engineer.

PART 2 PRODUCTS

2.01 FORMS

A. Wood Forms:
   1. Provide new and unused exterior grade plywood panels manufactured in accordance with American Plywood Association (APA) and bearing the trademark of that group.
      a. Forms for concrete surfaces exposed to view: use APA High Density Overlay (HDO) Plyform Class I Exterior 48" X 96" X 3/4".
      b. Forms for other concrete surfaces: use APA Douglas Fir B-B Plyform Class I Exterior 48" X 96" X 3/4-inch.
   2. When approved, plywood may be reused.

B. Metal Forms:
   1. Do not use aluminum. Provide forms free of rust and straight without dents to provide members of uniform thickness.

2.02 FORM TIES

A. Commercially fabricated for use in form construction. Fabricated so that ends or end fasteners can be removed without causing spalling at surfaces of the concrete. Cone on ends shall be 3/4 inch to 1 inch diameter. Provide embedded portion of tie not less than 1 1/2 inch from face of concrete after cone ends have been removed. Provide ties with integral waterstops at water-retaining and below grade structures.

B. Tapered through-bolts may be used when approved. Use 1-inch minimum diameter at the smallest end. Fill tapered tie holes after cleaning to produce watertight construction. Use a mechanical waterstop plug near the center of the wall and fill each side with non-shrink cement grout. Mechanical waterstop plug shall be Greenstreak Group, Inc. "X-Plug"; or equal.

2.03 FORM RELEASE COMPOUND

A. Coat form surfaces in contact with concrete using a non-staining, non-residual, water based, bond-breaking form coating. [Use NSF approved form release agents in potable water containment structures.]

PART 3 EXECUTION

3.01 PREPARATION

A. Cover surface of forms with form release compound prior to form installation in accordance with manufacturer's recommendations.

B. Do not permit excess form coating material to stand in puddles on forms or hardened concrete surfaces against which fresh concrete is to be placed.

C. Clean surfaces of forms, reinforcing steel and other embedded items of accumulated mortar, grout, or other foreign materials from previous concreting or construction activities before concrete is placed.

3.02 FORMWORK CONSTRUCTION

A. Form vertical surfaces of cast-in-place concrete including sides of footings.

B. Construct and place forms so that the resulting concrete will be of the shape, lines, dimensions, and appearance indicated on the Drawings. Brace or tie forms together to maintain position and shape under the load of freshly-placed concrete.

C. Tighten forms to prevent leakage.

D. Provide temporary openings(windows) at base of column and wall forms and at other points where necessary to facilitate cleaning and observation immediately before concrete is placed.

E. Provide temporary openings to limit height of free fall of concrete and to limit the lateral movement of concrete during placement. Openings are required in wall placements greater than 20 feet in height, spaced no more than 8 feet on center measured horizontally and vertically.

F. Place a 3/4-inch chamfer strip at exposed to view corners of formed surfaces.

G. At construction joints, overlap hardened concrete surface by at least 1 inch. Brace forms against hardened concrete to prevent movement, offsets, or loss of mortar at construction joint and to maintain a true surface. Where possible, locate juncture of built-in-place forms at architectural lines, control joints, or at other inconspicuous lines.

H. Where circular sections are formed using flat faced materials, use flat form lengths not exceeding 2 feet wide and the resulting deflection angles at the joints is not greater than 3-1/2 degrees.

I. Construct wood forms for openings to facilitate loosening. Anchor forms so that movement of any part of the formwork system is prevented during concrete placement.

J. At platforms constructed to move equipment over in-place reinforcement, provide beams, struts, and/or legs, supported directly on formwork or other structural members without resting on reinforcing steel.

K. Provide a positive means of adjustment (wedges or jacks) at shores and struts to take up settlement during concrete placement. Brace forms against lateral deflection. Fasten in-place wedges and shims used for final adjustment of forms prior to concrete placement.

L. Place tapered through-bolt form ties with the larger end on the side of the structure in contact with liquid.

3.03 TOLERANCES

A. Install formwork with tolerances in accordance with ACI 117 and the following (the more stringent requirement controls):

1. Install formwork in accordance with manufacturer's written instructions.
2. Vertical surface tolerance from plumb; walls, columns, piers, and risers:
   ± 1/2 inch for entire height
   ± 1/4 inch in any 10 feet of height
3. Vertical surface tolerance from plumb; exposed wall corners, end columns, control-joint grooves, and other exposed to view vertical lines:
   ± 1/2 inch for entire height
   ± 1/4 inch in any 20 feet of height
4. Horizontal variation from level or from grade; top of slabs, slab soffits, ceilings, and beam soffits, measured before removal of supporting shores:
   ± 3/4 inch for entire length
   ± 3/8 inch for any bay or 20 foot length
   ± 1/4 inch in any 10 feet of length
5. Horizontal variation from level or from grade; exposed lintels, sills, parapets, horizontal grooves, and other exposed-to-view horizontal lines:
   ± 1/2 inch for entire length
   ± 1/4 inch in any 20 feet of length.
6. Plan position variation; columns, walls, and partitions:
   ± 3/4 inch for entire length
   ± 3/8 inch for any bay or 20 foot length
7. Plan location and size; sleeves, floor openings, walls, wall openings, beams, and columns:
   ± 1/2 inch
8. Cross sectional dimensions; columns and beams and thickness of slabs and walls:
   ± 3/8 inch
9. Plan dimensions; footings and foundations:
   minus 1/2 inch
   + 2 inches
10. Misplacement or eccentricity; footings and foundations:
    2 percent of footing width in direction of misplacement
    not more than 2 inches

11. Thickness; footings and foundations:
    minus 5 percent
    no limit on the maximum increase except that which may interfere with other construction.
12. Step variance in flight of stairs:
    Rise ± 1/16 inch
    Tread from level ± 1/8 inch

B. Use control points and benchmarks for reference purposes to check tolerances. Establish and maintain reference points in an undisturbed condition until final completion and acceptance of the work.

C. Regardless of tolerances listed, no portion of a structure shall extend beyond the legal boundary of work site.

D. Camber formwork to compensate for anticipated deflections in formwork under wet load of concrete. Adjust camber to maintain above specified tolerances in hardened concrete after forms and shoring are removed.

3.04 REMOVAL OF FORMS

A. Do not impose construction loads or remove shoring from any part of the structure until that portion of the structure in combination with remaining forming and shoring systems has sufficient strength to safely support its weight and loads placed thereon.

B. If forms are loosened and not removed, proceed same day with wet curing operations to soak surfaces of concrete where forms are loosened. When wet curing is not practical or not planned, loosen, remove, and start approved curing procedures on the same day.

C. When required for concrete curing in hot weather, required for repair of surface defects, or when required for finishing at an early age; remove forms as soon as concrete has hardened sufficiently to resist damage from removal operations or lack of support.

D. Remove top forms on sloping surfaces as soon as concrete has attained sufficient stiffness to prevent sagging. Make repairs or finishing treatment on such sloping surfaces immediately after form removal.

E. Remove wood forms for wall openings as soon as this can be accomplished without damage to concrete.

F. Remove formwork from columns, walls, sides of beams, and other parts not supporting weight of concrete as soon as concrete has hardened sufficiently to resist damage from removal.

G. When shores and supports are so arranged such that non-load-carrying form facing material can be removed without loosening or disturbing other shores and supports, facing material may be removed when concrete has sufficiently hardened to resist damage from removal.

H. In all cases, proceed with curing same day as form removal.

I. Where no reshoring is planned, forms and shoring used to support weight of concrete shall be left in place until concrete has attained its specified 28-day compressive strength.

3.05 RESHORING

A. Do not impose construction loads or remove shoring from any part of the structure until that portion of the structure, in combination with remaining forming and shoring systems, has sufficient strength to safely support its weight and loads placed thereon.

B. While reshoring is underway, no superimposed dead or live loads are permitted on the new construction.

C. During reshoring, do not subject concrete in structural members to combined dead and construction loads in excess of loads that the structural members can adequately support.

D. Place reshores as soon as practicable after stripping operations are complete, but in no case later than the end of working day on which stripping occurs.

E. Place reshores to carry their required loads without overstressing.

F. Where a reshoring procedure is planned, supporting formwork may be removed when concrete has reached the concrete strength specified by the formwork engineer's structural calculations and verified by field cured test cylinders or other approved method.

END OF SECTION

SECTION 03 20 00

CONCRETE REINFORCING

PART 1 GENERAL

1.01 DESCRIPTION

A. Section includes: Reinforcing steel for use in reinforced concrete.

1.02 REFERENCES:

A. The references listed below are a part of this section. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.

Reference	Title
ACI 117	Specification for Tolerances for Concrete Construction and Materials
ACI 315	Details and Detailing of Concrete Reinforcement
ACI 318	Building Code Requirements For Structural Concrete
ACI SP-66	ACI Detailing Manual
ASTM A615	Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement
ASTM A706	Low-Alloy Steel Deformed and Plain Bars for Concrete Reinforcement
ASTM A775	Epoxy-Coated Steel Reinforcing Bars
ASTM A884	Epoxy-Coated Steel Wire and Welded Wire Reinforcement
ASTM A1064	Carbon-Steel Wire and Welded Wire Reinforcement, Plain and Deformed, for Concrete
AWS D1.4	Structural Welding Code - Reinforcing Steel
CRSI-PRB	Placing Reinforcing Bars
CRSI-MSP	Manual of Standard Practice
FEDSPEC QQ-W-461H	Wire, Steel, Carbon (Round, Bare, and Coated)

1.03 SUBMITTALS

A. Action Submittals

1. Procedures: Section 01 33 00.
2. A copy of this specification section with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements.
3. Check-marks (✓) shall denote full compliance with a paragraph as a whole. Deviations shall be underlined and denoted by a number in the margin to the right of the identified paragraph. The remaining portions of the paragraph not underlined will signify compliance on the part of the Contractor with the specifications. Include a detailed, written justification for each deviation. Failure to include a copy of the marked-up specification sections, along with justification(s) for any requested deviations to the specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration.
4. Mill certificates of mill analysis, tensile, and bend tests for all reinforcing.

5. Manufacturer and type of proprietary reinforcing steel splices. Submit a current ICC Report and manufacturer's literature that contains instructions and recommendations for each type of coupler used.
6. Qualifications of welding operators, welding processes and procedures.
7. Reinforcing steel shop drawings showing reinforcing steel bar quantities, sizes, spacing, dimensions, configurations, locations, mark numbers, lap splice lengths and locations, concrete cover and reinforcing steel supports. Reinforcing steel shop drawings shall be of sufficient detail to permit installation of reinforcing steel without reference to the contract drawings. Shop drawings shall not be prepared by reproducing the plans and details indicated on the contract drawings but shall consist of completely redrawn plans and details as necessary to indicate complete fabrication and installation of reinforcing steel, including large scale drawings at joints detailing bar placement in congested areas. Placement drawings shall be in accordance with ACI 315. Reinforcing details shall be in accordance with ACI SP-66.

1.04 DELIVERY, STORAGE AND HANDLING

A. Ship reinforcing steel to the jobsite with attached plastic or metal tags having permanent mark numbers which match the shop drawing mark numbers. All reinforcing shall be supported and stored above ground. Use only plastic tags secured to the reinforcing steel bars with nylon or plastic tags for epoxy coated reinforcing steel bars.

PART 2 PRODUCTS

2.01 BAR REINFORCEMENT

A. Reinforcing steel bars shall be deformed billet steel in conformance with ASTM A615, Grade 60. Bars to be welded shall be deformed billet steel conforming to ASTM A706. Where specified, reinforcing steel shall be epoxy-coated in conformance with ASTM A775.

2.02 WIRE FABRIC

A. Wire fabric shall be welded steel mesh conforming to ASTM A1064.

2.03 WIRE AND PLAIN BARS

A. Wire used as reinforcement and bars used as spiral reinforcement in structures shall be cold drawn steel conforming to ASTM A1064.

2.04 SMOOTH DOWEL BARS

A. Smooth dowel bars shall conform to ASTM A615, Grade 60, with a metal end cap at the greased or sliding end to allow longitudinal movement.

2.05 EPOXY COATED BARS

A. Epoxy coated bars shall conform to ASTM A775 and ASTM A884.

2.06 EPOXY COATED REINFORCING STEEL BAR PATCHING MATERIAL

A. Epoxy coated reinforcing steel bar patching material shall be compatible with coating material, inert in concrete, obtained from manufacturer of the epoxy resin used to coat the reinforcing steel bars and meet the requirements of ASTM A775.

2.07 REINFORCING STEEL MECHANICAL SPLICES

A. Reinforcing steel mechanical splices shall be a positive connecting threaded type mechanical splice system manufactured by Erico, Inc., Dayton Superior, Williams Form Engineering Company, or approved equal.

B. Type 1 mechanical splices shall develop in tension or compression a strength of not less than 125 percent of the ASTM specified minimum yield strength of the reinforcement and shall meet all other ACI 318 requirements. Where splices at the face of wall are shown or approved, form saver-type mechanical couplers may be used. Form-saver couplers shall have integral plates designed to positively connect coupler to formwork. Type 1 mechanical splices are typical except for locations noted below where Type 2 mechanical splices are required.

2.08 TIE WIRE

A. The wire shall be minimum 16 gage annealed steel conforming to FEDSPEC QQ-W-461H.

2.09 BAR SUPPORTS

A. Bar supports coming into contact with forms shall be CRSI Class 1 plastic protected or Class 2 stainless steel protected and shall be located in accordance with CRSI-MSP and placed in accordance with CRSI-PRB. Plastic coating on legs shall extend at least 0.5-inch upward from form surface.

B. Provide precast concrete blocks, four inches square in plan, with embedded tie wires (wire dobies) as specified by CRSI 1 MSP for footing and slabs on grade. Do not use brick, broken concrete masonry units, spalls, rocks, construction debris, or similar material for supporting reinforcing steel. Precast concrete blocks shall have same or higher compressive strength as specified for concrete in which they are located.

C. Provide stainless steel or plastic protected plain steel supports for other work.

2.10 FABRICATION:

A. Fabricate reinforcing steel bars in accordance with ACI 315 and the following tolerances:
   1. Sheared lengths: +/-1 inch.
   2. Overall dimensions of stirrups, ties, and spirals: +/-1/2 inch.
   3. All other bends: +0 inch, -1/2 inch
   4. Minimum diameter of bends of reinforcing steel bars: Per ACI 318.

PART 3 EXECUTION

3.01 PLACEMENT TOLERANCE

A. Reinforcing steel placement tolerance shall conform to the requirements of ACI 117, ACI 318, and the following:
   1. Reinforcing steel bar clear distance to formed surfaces shall be within +/-1/4 inch of specified clearance and minimum spacing between bars shall be a maximum of 1/4 inch less than specified.
   2. Reinforcing steel top bars in slabs and beams shall be placed +/-1/4 inch of specified depth in members 8 inches deep or less and -1/4", +1/2 inch of specified depth in members greater than 8 inches deep.
   3. Reinforcing steel spacing shall be placed within +/- one bar diameter or +/- 1 inch, whichever is greater.
   4. The minimum clear distance between reinforcing steel bars shall be equal to the greater of 1 inch or the reinforcing steel bar diameter for beams, walls and slabs, and the greater of 1 1/2 inches or 1.5 times the reinforcing steel bar diameter for columns.
   5. Beam and slab reinforcing steel bars shall be threaded through column vertical reinforcing steel bars without displacing the column reinforcing steel bars and still maintain clear distances for beam and slab reinforcing steel bars.

3.02 CONCRETE COVER

A. Unless specified otherwise on the Drawings, reinforcing steel bar cover shall conform to the following:
   1. Reinforcing steel bar cover shall be 3 inches for concrete cast against earth.
   2. Reinforcing steel bar cover shall be 2 inches for reinforcing steel bars for formed concrete surfaces exposed to earth and weather.
   3. Reinforcing steel bar cover shall be 2 inches for any formed surfaces exposed to or above any liquid.
   4. Reinforcing steel bar cover shall be 1 ½ inches for reinforcing not in the above categories unless noted otherwise on the design drawings.

3.03 SPLICING

A. Reinforcing steel splicing shall conform to the following:
   1. Use Class B splice lengths in accordance with ACI 318 for all reinforcing steel bars unless shown otherwise on the drawings.
   2. For welded wire fabric the splice lap length measured between the outermost cross wires of each fabric sheet shall not be less than one spacing of cross wires plus 2 inches, nor less than 1.5 times the development length nor less than 6 inches.
   3. Splices of reinforcement steel bars not specifically indicated or specified shall be subject to the approval of the Owner's Representative. Mechanical proprietary splice connections may be used when approved by the Owner's Representative or as indicated on the drawings.
   4. Welding of reinforcing steel bars is not allowed unless approved by the Owner's Representative.

3.04 CLEANING

A. Reinforcing steel bars at time of concrete placement shall be free of mud, oil, loose rust, or other materials that may affect or reduce bond. Reinforcing steel bars with rust, mill scale or a combination of both may be accepted without cleaning or brushing provided dimensions and weights including heights of deformation on a cleaned sample are not less than required by applicable ASTM standards.

3.05 PLACEMENT

A. Reinforcing steel bar placement shall conform to the following:
   1. Uncoated reinforcing steel bars shall be supported and fastened together to prevent displacement by construction loads or concrete placement. For concrete placed on ground, furnish concrete block supports or metal bar supports with non-metallic bottom plates. For concrete placed against forms furnish plastic or plastic coated metal chairs, runners, bolsters, spacers and hangers for the reinforcing steel bar support. Only tips in contact with the forms require a plastic coating.
   2. Fasten coated reinforcing steel bars together to prevent displacement. Use plastic or nylon ties to hold the coated reinforcing steel bars rigidly in place. Support coated reinforcing steel bars with plastic or plastic coated chairs, runners, bolsters, spacers and supports as required.
   3. Support reinforcing steel bars over cardboard void forms by means of concrete supports which will not puncture or damage the void forms nor impair the strength of the concrete member.
   4. Where parallel horizontal reinforcement in beams is indicated to be placed in two or more layers, reinforcing steel bars in the upper layers shall be placed directly over the reinforcing steel bars in the bottom layer with the clear distance between each layer to be 2 inches unless otherwise noted on the Drawings. Place spacer reinforcing steel bars at a maximum of 3'-0" on center to maintain the minimum clear spacing between layers.
   5. Extend reinforcement to within 2 inches of formed edges and 3 inches of the concrete perimeter when concrete is placed against earth.
   6. Reinforcing steel bars shall not be bent after embedding in hardened concrete unless approved by the Owner's Representative.
   7. Tack welding or bending reinforcing steel bars by means of heat is prohibited.
   8. Where required by the contract documents, reinforcing steel bars shall be embedded into the hardened concrete utilizing an adhesive anchoring system specifically manufactured for that application. Installation shall be per the manufacturer's written instructions.
   9. Bars with kinks or with bends not shown shall not be used.
   10. Heating or welding bars shall be performed in accordance with AWS D1.4 and shall only be permitted where specified or approved by the Owner's Representative. Bars shall not be welded at the bend.

3.06 REPAIR OF EPOXY COATING

A. Epoxy coating damage need not be repaired in cases where the damaged area is 0.1 square inch or smaller. Repair all damaged areas larger than 0.1 square inch in conformance with ASTM A775.

3.07 FIELD QUALITY CONTROL

A. Field quality control shall include the following:

1. Notify the Owner's Representative whenever the specified clearances between the reinforcing steel bars cannot be met. The concrete shall not be placed until the Contractor submits a solution to the congestion problem and it has been approved by the Owner's Representative.
2. The reinforcing steel bars may be moved as necessary to avoid other reinforcing steel bars, conduits or other embedded items provided the tolerance does not exceed that specified in this section. The Engineer's approval of the modified reinforcing steel arrangement is required where the specified tolerance is exceeded. No cutting of the reinforcing steel bars shall be done without written approval of the Owner's Representative.
3. Coated reinforcing steel bars will be inspected on the jobsite for handling defects, coating abrasion, coating thickness and continuity of coating. The Owner's Representative may defer final inspection of the coated reinforcing steel bars until bar erection and handling is complete. Repair coated areas as directed by the Owner's Representative and completed prior to concrete placement.
4. An independent laboratory shall be employed to review and approve Contractor welding procedures and qualify welders in accordance with AWS D1.4. The laboratory shall visually inspect each weld for visible defects and conduct non-destructive field testing (radiographic or magnetic particle) on not less than one sample for each 10 welds. If a defective weld is found, the previous 5 welds by the same welder shall also be tested.

END OF SECTION

SECTION 03 30 00

CAST-IN-PLACE CONCRETE

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Cast-in-place concrete, which consists of providing material, mixing, transporting equipment, and labor for the proportioning, mixing, transporting, placing, consolidating, finishing, curing, and protection of concrete in the structure.

1.02 RELATED SECTIONS

A. This section contains specific references to the following related specification sections. Additional related sections may apply that are not specifically listed below.
   1. Section 03 60 00 Grouting
   2. Section 05 50 00 Metal Fabrications
   3. Section 09 90 00 Painting and Coating

1.03 REFERENCES

A. The references listed below are a part of this section. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.

Reference	Title
ACI 117	Specification for Tolerances for Concrete Construction and Materials
ACI 211.1	Standard Practice for Selecting Proportions for Normal, Heavyweight and Mass Concrete
ACI 214R	Guide to Evaluation of Strength Test Results in Concrete
ACI 301	Specifications for Structural Concrete
ACI 305.1	Specification for Hot Weather Concreting
ACI 306.1	Standard Specification for Cold Weather Concreting
ACI 318	Building Code Requirements for Structural Concrete
ACI 350	Code Requirements for Environmental Engineering Concrete Structures
ACI 350.1	Specification for Tightness Testing of Environmental Engineering Concrete Containment Structures
ACI 503.7	Specification for Crack Repair by Epoxy Injection
ASTM A126	Gray Iron Castings for Valves, Flanges, and Pipe Fittings
ASTM C31	Making and Curing Concrete Test Specimens in the Field
ASTM C33	Concrete Aggregates
ASTM C39	Compressive Strength of Cylindrical Concrete Specimens
ASTM C42	Obtaining and Testing Drilled Cores and Sawed Beams of Concrete
ASTM C94	Ready-Mixed Concrete
ASTM C117	Materials Finer Than 75-μm (No. 200) Sieve in Mineral Aggregates by Washing
ASTM C131	Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine
ASTM C136	Sieve Analysis of Fine and Coarse Aggregates

Reference	Title
ASTM C143	Slump of Hydraulic Cement Concrete
ASTM C150	Portland Cement
ASTM C157	Length Change of Hardened Hydraulic-Cement Mortar and Concrete
ASTM C172	Sampling Freshly Mixed Concrete
ASTM C192	Making and Curing Concrete Test Specimens in the Laboratory
ASTM C231	Air Content of Freshly Mixed Concrete by the Pressure Method
ASTM C260	Air-Entraining Admixtures for Concrete
ASTM C309	Liquid Membrane-Forming Compounds for Curing Concrete
ASTM C494	Chemical Admixtures for Concrete
ASTM C511	Mixing Rooms, Moist Cabinets, Moist Rooms, and Water Storage Tanks Used in the Testing of Hydraulic Cements and Concretes
ASTM C595	Blended Hydraulic Cements
ASTM C618	Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete
ASTM C881	Epoxy-Resin-Base Bonding Systems for Concrete
ASTM C989	Slag Cement for use in Concrete and Mortars
ASTM C1059	Latex Agents for Bonding Fresh to Hardened Concrete
ASTM C1077	Agencies Testing Concrete and Concrete Aggregates for Use in Construction and Criteria for Testing Agency Evaluation
ASTM C1240	Silica Fume Used in Cementitious Mixtures
ASTM C1260	Potential Alkali Reactivity of Aggregates (Mortar-Bar Method)
ASTM C1293	Determination of Length Change of Concrete Due to Alkali-Silica Reaction
ASTM C1315	Liquid Membrane-Forming Compounds Having Special Properties for Curing and Sealing Concrete
ASTM C1567	Potential Alkali-Silica Reactivity of Combinations of Cementitious Materials and Aggregate (Accelerated Mortar-Bar Method)
ASTM C1602	Mixing Water Used in the Production of Hydraulic Cement Concrete
ASTM D75	Sampling Aggregates
ASTM D2419	Sand Equivalent Value of Soils and Fine Aggregate
ASTM E329	Agencies Engaged in Construction Inspection, Testing, or Special Inspection
CRD-C572	U.S. Corps of Engineer's Specifications for Polyvinylchloride Waterstop
IBC	International Building Code with local amendments

1.04 SUBMITTALS

A. Action Submittals:

1. Procedures: Section 01 33 00.
2. A copy of this specification section with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements.
3. Check-marks (✓) denote full compliance with a paragraph as a whole. Deviations shall be underlined and denoted by a number in the margin to the right of the identified paragraph. The remaining portions of the paragraph not underlined signify compliance with the specification. Include a detailed, written justification for each deviation. Failure to include a copy of this marked-up specification section, along with justification(s) for requested deviations, with the submittal, is cause for rejection of the entire submittal with no further consideration.

4. Each proposed mix design showing:
    a. Expected strength at 7 and 28-days.
    b. Slump, before and after introduction of high-range water-reducing admixture.
    c. Water/cement ratio.
    d. Weights and test results, certifications, and mill reports of the ingredients.
    e. Chemical analysis report and report of other specified test analyses for supplementary cementitious material.
    f. Aggregate gradation and documentation of test results classifying aggregate as non-potentially reactive.
    g. Test results of mix design prepared by an independent testing laboratory.
    h. Shrinkage test results for liquid containing structures.
    i. Other physical properties necessary to review each mix design for conformance with these specifications.
5. Mix designs proposed shall be sealed by a Professional Engineer registered in Oregon.
6. Product literature and technical data for aggregates, cement, and pozzolan.
7. Product literature, technical data, and dosage of proposed admixtures including, but not limited to, air entraining, water reducing, retarding, shrinkage reducing, etc.
8. Anticipated average delivery time from batch plant to site. If this time exceeds the limit specified in Part 3, include proposed method to extend set time without deleterious effects on final product. Owner's Representative reserves the right to accept or reject such proposed methods.
9. Lift Drawings: Submit shop drawings for concrete placements on the project before on-site construction begins. The drawings shall be organized by structure and submitted as a complete set for the Engineer's review. The drawings shall be drawn to scale and show dimensions, forming details, placement volumes and location of construction joints.
10. Curing program description in sufficient detail to demonstrate that the Contractor will provide acceptable strength, finish, and crack control within the completed structure. Detailed plan for curing and protection of concrete in cold and hot weather.
11. Alternate method of construction joint preparation if applicable.
12. Product literature and technical data for waterstops, curing and sealing compounds, bonding compounds, surface hardeners, epoxy and chemical grout for crack injection, retardant, bearing pads, and trench drains.
13. Concrete delivery truck tickets showing the information listed in ASTM C94, Section 14.
14. Product data for prefabricated trench drains: material properties, cover, dimensions, and manufacturer's installation instructions.

1.05 QUALITY ASSURANCE

A. Quality Control By Owner:
   1. Special Inspection of concrete work shall be performed by the Special Inspector under contract with the Owner and in conformance with the IBC Chapter 17. Special Inspection of concrete is in addition to, not replacing, other inspections and quality control requirements specified herein. Where sampling and testing specified herein conforms to Special Inspection standards, such sampling and testing need not be duplicated.
   2. All structural concrete work shall receive Special Inspection in accordance with IBC Chapter 17. Structural concrete includes elements which resist code-defined loads and whose failure would impact life safety. Non-structural site work concrete does not require Special Inspection. Anchor bolts and anchors installed in hardened concrete require Special Inspection.

B. Basis For Quality:
   1. Cast-in-place concrete shall conform to the requirements of ACI 301, except as modified herein.

PART 2 PRODUCTS

2.01 MATERIALS

A. Cement:
   1. Portland cement shall be ASTM C150, Type II or Type V, low alkali, containing less than 0.60 percent alkalis. In addition to standard requirements, cement shall satisfy optional chemical and physical requirements of ASTM C150, Tables 2 and 4, respectively.
   2. If low alkali portland cement is not available, test results shall be submitted showing aggregates meet the alkali-silica reactivity criteria in 2.01.D.1.b below.
   3. Portland-pozzolan cement shall be ASTM C595, Type IP (MS), interground, low alkali.
   4. Portland blast-furnace slag cement shall be ASTM C595, Type IS (<70) (MS), interground, low alkali.
   5. Portland-limestone cement shall be ASTM C595, Type IL (MS), interground, low alkali. In addition to meeting all testing requirements within ASTM C595 (Tables 1-3), cement certification shall also include chemical test for $C_3A<8\%$ to match existing Type II characteristics.
   6. Hydraulic cements meeting the performance specifications of ASTM C1157 are not permitted.
   7. Use cementitious materials that are of the same brand and type and from the same plant of manufacture as the cementitious materials used in the concrete represented by the submitted field test records or used in the trial mixtures. See Change of Materials paragraph below.

B. Ground granulated blast-furnace slag (GGBFS), if used in conjunction with portland cement, shall be per ASTM C989, Grade 100 or Grade 120, limited to 50 percent of the weight of cementitious materials. If GGBFS is combined with pozzolans and/or silica fume, the total weight of GGBFS, pozzolans, and silica fume shall not exceed 50 percent of the weight of cementitious materials.

C. Silica fume, if used in conjunction with portland cement, shall be per ASTM C1240, limited to 10 percent of the weight of cementitious materials. Silica fume shall be used with a high-range water-reducing admixture.

D. Aggregates:
   1. General:
      a. Except as modified herein, fine and coarse aggregates shall conform to ASTM C33. Fine and coarse aggregates are regarded as separate ingredients. Aggregates shall be non-reactive and washed before use.
      b. Check aggregates for alkali-silica reactivity to meet the following criteria. Aggregates or combinations of cementitious materials and aggregates shall have less than 0.10% expansion at 16 days when tested in accordance with ASTM C1260 or ASTM C1567. Alternatively, aggregate tested independently in accordance with ASTM C1293 shall have less than 0.04% expansion at one-year, or combinations of aggregate and cementitious materials tested in accordance with ASTM C1293 shall have less than 0.04% expansion at two years. Test results shall be no older than 2 years.
      c. Tests for size and grading of fine and coarse aggregates shall be in accordance with ASTM C136. Combined aggregates shall be well and uniformly graded from coarse to fine sizes to produce a concrete that has optimum workability and consolidation characteristics. Establish the final combined aggregate gradation during mix design.
      d. Aggregates used in the project production concrete shall be obtained from the same sources and have the same size ranges as the aggregates used in the concrete represented by the submitted historical data or trial mixtures. See Change of Materials paragraph below.
   2. Fine Aggregate:
      a. Fine aggregate shall be hard, dense, durable particles of either sand or crushed stone regularly graded from coarse to fine. Gradation shall conform to ASTM C33. For classes of concrete which will be used in liquid retaining structures, fine aggregate shall not exceed 40 percent by weight of combined aggregate total, except for concrete with coarse aggregate of less than maximum size 1/2 inch.
      b. Variations from the specified gradations in individual tests will be acceptable if the average of three consecutive tests is within the specified limits and the variation is within the permissible variation listed below:

U.S. standard sieve size	Permissible variation in individual tests, percent
30 and coarser	2
50 and finer	0.5

      c. Other tests shall be in accordance with the following specifications:

Test	Test method	Requirements
Amount of material	ASTM C117	3 percent passing No. 200 sieve maximum by weight
Sand equivalent	ASTM D2419	Minimum 70 percent

3. Coarse Aggregate:
    a. Coarse aggregate shall be hard, dense and durable gravel or crushed rock free from injurious amounts of soft and friable particles, alkali, and organic matter. Other deleterious substances shall not exceed the limits listed in ASTM C33, Table 4 for Class Designation 4S. Gradation of each coarse aggregate size specified shall conform to ASTM C33, Table 3.
    b. Variations from the specified gradations will be acceptable in individual tests if the average of three consecutive tests is within the specified limits.

E. Pozzolan:
1. Pozzolan shall be Class N, natural pozzolan, or Class F fly ash conforming to ASTM C618. Class C fly ash is not allowed. Pozzolan supplied during the life of the project shall have been formed at the same single source. See Change of Materials paragraph below.
2. The pozzolan color shall not substantially alter the resulting concrete from the normal gray color and appearance.
3. Use pozzolan materials that are of the same brand and type and from the same plant of manufacture as the materials used in the concrete represented by the submitted field test records or used in the trial mixtures.
4. The loss on ignition shall be a maximum of 4 percent.
5. The maximum percent of sulfur trioxide (SO3) shall be 4.0.

F. Admixtures:
1. General:
    a. Admixtures shall be compatible with the concrete and with each other. Calcium chloride or admixtures containing calcium chloride are not acceptable. Use admixtures in accordance with the manufacturer's recommendations and add separately to the concrete mix. Water reducing retarders and admixtures shall reduce the water required by at least 11 percent for a given concrete consistency and shall comply with the water/cement ratio standards of ACI 211.1. Retarder dosage shall result in set time consistent with requirements specified in Part 3.
2. Water Reducing Admixtures:
    a. Conform to ASTM C494, Type A. Acceptable products include: BASF Corporation “MasterPozzolith Series”; SIKA Chemical Corp. “Plastocrete 161”; Euclid Chemical Co. “Eucon WR 91”; or approved equal.
3. Water Reducing and Retarding Admixtures:
    a. Conform to ASTM C494, Type D. Acceptable products include: BASF Corporation “MasterSet R Series”; Sika Chemical Corp. “Plastiment”; Euclid Chemical Co. “Eucon Retarder 75”; or approved equal.
4. High Range Water Reducing (Superplasticizing) Admixtures:
    a. Conform to ASTM C494, Type F. Acceptable products include: BASF Corporation “MasterGlenium” Series; Sika Chemical Corp. “Viscocrete 2100” or “Viscocrete 2110” (Hot Weather) or “Viscocrete 6100” (Cold Weather); Euclid Chemical Co. “Eucon 37”; GCP Applied Technologies “ADVA 195”; or approved equal.

5. High Range Water Reducing And Retarding Admixtures:
    a. Conform to ASTM C494, Type G. Acceptable products include: GCP Applied Technologies “Daracem 100”; Sika Chemical Corp. “Sikaplast 200” ; Euclid Chemical Co. “Eucon 537”; or approved equal.
6. Air Entraining Agent:
    a. Conform to ASTM C260 and produce air entrained concrete as specified in the Mix Proportioning table below. Acceptable products include: BASF Corporation “MasterAir Series”; Sika Chemical Corp. “Sika AEA-14” or “Sika AIR” ; Euclid Chemical Co. “Eucon AEA-92”; or approved equal.
7. Shrinkage Reducing Admixture:
    a. Select admixture for compatibility with air entrainment admixture and other ingredients in the concrete mix. Acceptable products include: BASF Corporation “MasterLife SRA Series”; GCP Applied Technologies “Eclipse 4500”; or approved equal.

G. Water:
1. For washing aggregate, mixing, and for curing shall be free from oil and deleterious amounts of acids, alkalis, and organic materials; comply with the requirements of ASTM C1602. Additionally, water used for curing shall not contain an amount of impurities sufficient to discolor the concrete.

H. Change of Materials:
1. After each concrete mix design is approved, no changes of any sort or source will be allowed without prior written approval from the Engineer. When brand, type, size, or source of cementitious materials, aggregates, water, ice, or admixtures are proposed to be changed, new field data, data from new trial mixtures, or evidence that indicates that the change will not affect adversely the relevant properties of the concrete shall be submitted for approval by the Engineer before use in concrete.

2.02 CONCRETE CHARACTERISTICS

A. Mix Proportioning:
1. Concrete shall be normal weight concrete composed of cement, pozzolan, admixtures, aggregates, and water; proportioned and mixed to produce a workable, strong, dense, and impermeable concrete. It is acceptable to substitute interground Portland-pozzolan cement conforming to ASTM C595, containing the specified amount of pozzolan in lieu of Portland cement and pozzolan. Water-cementitious material (w/cm) ratio is based on the combined contents of cement and pozzolan.
2. Provide concrete mix designs in accordance with the following guidelines:

    (I thought this was going to coordinate without Concrete Submittal data)

Concrete class	Minimum 28-day compressive strength, psi	ASTM coarse aggregate size	Maximum water-cementitious materials (w/cm) ratio	Minimum cementitious materials content (pounds/CY)	Pozzolan, percent by weight of cementitious materials	Air content (percent)	Slump range[e] (inches)
B	3000	57 or 67	0.45	560	15-25[d]	4-6	3-5
C-1	4500	57 or 67	0.38	560	20-25	3.5-6.5	5-8

[a] *Determine compressive strength at the end of 28 days based on test cylinders made and tested in accordance with ASTM C39.*

[b] *Compressive strength of Class A concrete may be determined at 56 days.*

[c] *Concrete encasement for electrical conduit shall contain 3 pounds of red oxide per sack of cement.*

[d] *Pozzolan use is optional for this class of concrete.*

[e] *Slump before addition of high range water reducing admixture (superplasticizer). Maximum slump after addition of high range water reducing admixture shall be 8".*

B. Use:

1. Provide concrete by class for the uses listed below.

Concrete Class	Type of Use
B	Non-structural concrete (sidewalks, curbs, pavers, etc.)
C-1	Typical cast-in-place structural concrete

[a] *Contractor's option to use the same concrete mix for pipe encasement as the concrete slab above.*

C. Control Tests:

1. General:
   a. Select and adjust proportions of ingredients in accordance with ACI 211.1. Verification of mix characteristics for submittal may be achieved using either the Trial Mix Design method or Field Experience Data method. Do not place concrete prior to submittal and acceptance of proposed mix.
2. Trial Mix Design:
   a. Mixes verified by this method shall have the samples produced for testing, manufactured at the batch plant which will supply concrete to the project, using materials proposed for the Work and material combinations listed above. Testing, data, and reporting shall conform to ACI 318 and the following:
      1) Required compressive strength used as the basis for selecting concrete proportions (f'cr) shall be the specified concrete strength (f'c) + 1000 psi for specified concrete strengths less than 3,000 psi and f'c + 1200 psi for specified concrete strengths between 3000 psi and 5000 psi.
      2) Make at least three different trial mixtures for each class of concrete qualified by the Trial Mix Design. Each trial mixture shall have a different w/cm ratio or different cementitious materials content that will produce a range of compressive strengths encompassing f'cr.
      3) Design trial mixtures to produce a slump within ¾ inch of the maximum specified and an air content within 0.5 percent of the maximum specified.
      4) For each w/cm ratio or cementitious materials content, cast and cure at least twelve standard test cylinders in accordance with ASTM C192. Four cylinders from each batch tested at age 7-days, 14-days, and 28-days or as required to comply with ACI 318.
      5) From results of the cylinder tests, plot a curve showing the relationship between w/cm ratio and compressive strength.
      6) From the curve of w/cm ratio versus compressive strength, select the w/cm ratio that will produce f'cr. This is the maximum w/cm ratio to be used unless a lower w/cm ratio is specified above.

3. Field Experience Data:
    a. When sufficient test data for a particular mix design is available which is identical or substantially similar to that proposed for use, Contractor may substitute use of this data in lieu of a trial mix design. Field data, reports, and analysis shall conform to ACI 318, except as modified herein.
        1) Historical mix design proportions for which data are submitted may vary from the specified mix within the following limits:
            a) f'c as specified or up to 500 psi above
            b) w/cm ratio as specified or lower
            c) pozzolan content within 5 percent of that specified
            d) maximum coarse aggregate size may not vary smaller, but gradation of coarse aggregate may vary
            e) slump after introduction of admixtures +0/-1 inch.
    b. Use of historical Field Experience Data does not allow modification of the project mix specifications herein without review and acceptance by the Engineer.
4. Shrinkage:
    a. Liquid containing structures using Class C-1 concrete mix are intended to be watertight. Provide test results for Class C-1 concrete mix meeting the following requirement: drying shrinkage limit of 0.042 percent in the laboratory at 35-days (7-days moist cure and 28-days drying) as tested in accordance with ASTM C157 and the following modifications:
        1) Wet cure specimens for a period of 7-days (including the period of time the specimens are in the mold). Wet cure may be achieved either through storage in a moist cabinet or room in accordance with ASTM C 511, or through storage in lime saturated water.
        2) Slump of concrete for testing shall match job requirements and need not be limited to restrictions as stated in ASTM C 157 section 8.4.
        3) Report results in accordance with ASTM C 157 at 0, 7, 14 & 28-days of drying.
    b. Concrete shall not be placed in the field prior to acceptance of the concrete mix. To meet the drying shrinkage limit, it is recommended that a shrinkage reducing admixture be considered for use in concrete for liquid containing structures.

2.03 WATERSTOPS

A. Polyvinyl Chloride (PVC):
1. Manufacture PVC waterstops from virgin polyvinyl chloride conforming to the Corps of Engineers Specification No. CRD-C572.
2. Use 6-inch by 3/8-inch flat ribbed waterstop in construction joints. Acceptable products include: Greenstreak Group, Inc. "Model 679"; Vinylex Waterstops and Accessories Model R638; or approved equal.
3. Use 9 inch by 3/8-inch ribbed with center bulb waterstop in expansion joints. Acceptable products include: Greenstreak Group, Inc. "Model 696"; Vinylex Waterstops and Accessories Model "RLB9-38"; or approved equal.
4. Use molded crosses, tees, and other shapes for changes of direction, intersections, and transitions as recommended by manufacturer.

B. Thermoplastic:

1. Acceptable products include: Greenstreak Group, Inc. “Westec Envirostop TPE-R”; Vinylex Waterstops and Accessories “Petro Stop”; or approved equal of similar profiles to above specified PVC waterstops.

C. Retro-Fit:

1. Use “Tee” or “L” shape as indicated with epoxy adhesive, stainless steel batten strips, and stainless steel adhesive anchors. Acceptable products include: Greenstreak Group, Inc Model “667” or approved equal.

D. Expanding (Hydrophilic) Waterstops:

1. Bentonite-free, made from unvulcanized rubber. Acceptable products include: Adeka Corporation “Ultra Seal MC-2010MN with P-201 adhesive/sealant”; Greenstreak Group, Inc. “Hydrotite CJ-1020-2K with Leakmaster LV-1 adhesive/sealant”; or approved equal. These are allowable for use only where indicated on the drawings or accepted in writing by Engineer. Provide adhesive/sealant approved by manufacturer plus concrete nails and fender washers to secure waterstop material in-place during concrete placement. The waterstop MUST be placed between two mats or curtains of steel reinforcement.
2. For limited cover applications or where only one mat or curtain of reinforcement is present, use Adeka Corporation “Ultra Seal KBA-1510FP”or approved equal.

2.04 BONDING COMPOUNDS

A. Epoxy resin bonding compounds for use in wet areas shall conform to ASTM C881 Types IV or V, Class A, B, or C depending on temperature at use. Acceptable products include: BASF Corporation “MasterEmaco ADH 327RS”; Sika Chemical Corporation “Sikadur 32”; or approved equal.

B. Non-epoxy bonding compounds for use in dry areas for non-structural bonding or as noted on the drawings shall conform to ASTM C1059 Type II. Acceptable products include: Penetron Specialty Products “Acrylic Bondcrete”; ChemMasters “Cretelox”; or approved equal.

C. Apply bonding compounds in accordance with the manufacturer’s instructions.

2.05 EPOXY FOR CRACK INJECTION

A. Use a two component, moisture insensitive, high modulus, injection grade, 100 percent solids, epoxy-resin blend. Consistency as required to achieve complete penetration into cracks. Material shall conform to ASTM C881 Type 1 Grade 1. Acceptable products include: Sika Corporation “Sikadur 52”; Adhesives Technology Corporation “Crackbond SLV302”; or approved equal.

B. Use epoxy injection for structural crack repairs except as noted below for non-structural cracks in liquid-containing concrete structures. The Engineer shall determine whether a crack is classified as structural or non-structural.

2.06 CHEMICAL GROUT FOR CRACK INJECTION

A. Use hydrophobic polyurethane grout at the Engineer's discretion as an alternative for sealing non-structural cracks in concrete structures intended to be watertight. Acceptable products for sealing hairline cracks include: GCP Applied Technologies "DE NEEF Flex SLV PURe" (must be used with DE NEEF Flex Cat PURe); or Sika Corporation "SikaFix HH LV" as appropriate for crack width; or approved equal. Coordinate with product supplier to verify and select appropriate product for crack widths to be injected.

2.07 SURFACE RETARDANT

A. Retardant for exposing aggregate for unformed surfaces in construction joints shall be Sika Corporation"Rugasol-S"; GCP Applied Technologies "Top-Cast"; or approved equal (including water blast method).

B. Apply retardant in accordance with manufacturer's instructions sufficient to assure a minimum penetration of 1/4 inch.

2.08 CURING AND SEALING COMPOUNDS

A. Acceptable products for non-potable water applications include: BASF Corporation "MasterKure CC 250SB"; Dayton Superior "Cure & Seal 25% J22UV"; or approved equal, conforming to ASTM C1315.

B. Acceptable products for potable water tanks include: Atlas Tech Products "Atlas Quantum-Cure 61"; or approved equal certified to conform to NSF/ANSI Standard 61.

C. Compound shall be clear and applied in accordance with the manufacturer's instructions.

D. Curing and sealing compound shall be certified compliant with final finish system if applicable.

2.09 TRENCH DRAINS

A. Use either field formed and cast with grate and frame, or utilize a pre-engineered manufactured trench drain system that conforms to the design load requirements of AASHTO H-20 in traffic areas or 300 pounds per square foot elsewhere. Include the following minimum requirements:
   1. A round or V-bottom channel, sloped to a minimum of 1/16-inch per foot. See drawings for channel cross section or size. If not shown, use 12 inches wide and deep (nominal) and confirm with Owner's Representative.
   2. Aluminum grating frame with anchors at 45 degrees into the surrounding concrete. Coat aluminum to prevent direct concrete contact.
   3. Aluminum grate conforming to Federal Specification RR-F-621C.
   4. A locking device which directly connects the grate to the frame.

B. Candidate manufacturers include: MultiDrain Systems, Atlanta, Georgia; ABT, Inc., Troutman, North Carolina; or approved equal.

PART 3 EXECUTION

3.01 GENERAL

A. Use only truck-mixed, ready-mixed concrete conforming to ASTM C94. Proportion materials by weighing.

B. Introduce pozzolan into the mixer with cement and other components of the concrete mix; do not introduce pozzolan into a wet mixer ahead of other materials or with mixing water.

C. Introduce water at the time of charging the mixer; additional water may be introduced within 90 minutes from charging the mixer, provided the specified w/c ration and slump is not exceeded and the maximum total water per the approved mix design is not exceeded.

D. Arrange with the testing laboratory for inspection as required to comply with these specifications.

E. Deliver concrete to the site and complete discharge within 110 minutes after introduction of water to the mixture. Extension of allowable time beyond this limit requires a Contractor proposed remedial action plan to be reviewed and accepted by the Owner's Representative.

3.02 CONVEYING AND PLACING CONCRETE

A. Convey concrete from the mixer to the forms in accordance with ACI 301. Remove concrete that has segregated in conveying from the site of the work.

B. Placing Concrete:
   1. General:
      a. Place concrete in accordance with ACI 301. Do not permit concrete to drop freely more than 4-ft (6-ft when superplasticizer is used).
   2. Placing Concrete By Pumping:
      a. Concrete placed by pumping is at Contractor's discretion and shall not be the cause to change or relax specified mix design characteristics. Concrete shall possess the specified characteristics at the point of placement.
      b. Measure slump at the hose discharge, except as follows: Initial slump testing in each placement shall occur at both the pumping unit inlet hopper and hose discharge. Slump loss in pumping, measured between the inlet hopper and the hose discharge, shall not exceed 1 inch. After these criteria have been satisfied, slump may be measured at the inlet hopper with allowable slump increased by the earlier measured difference, not to exceed 1 inch.
      c. Measure air content at the hose discharge, except as follows: Initial air content testing shall occur at both the pumping unit inlet hopper and the hose discharge. Loss of air content shall be measured between the inlet hopper and the hose discharge. Increase the air content of the delivered concrete at the inlet hopper to provide the specified air content at the hose discharge. After these criteria have been satisfied, air content may be measured at the inlet hopper.

d. Before starting each pumping operation, prime the pump and line with a cement slurry to lubricate the system. Waste cement slurry outside the forms. Equip hose tip with a safety chain for recovery in case of hose blowout during pumping. Hose or accessories shall not remain in the freshly placed concrete.

e. Use tremie placing techniques and equipment for pump placed concrete. Pump discharge system shall remain full of concrete from pump to discharge point at all times. Concrete pumping shall not occur until Owner's Representative has verified equipment including the tremie plug. Should the discharge line become open, with zones empty of concrete, cease pumping and re-primed with tremie plug installed before continuing.

3. Placing Concrete In Hot Weather:

a. In temperatures above 80 degrees F, place concrete in accordance with ACI 305.1.

4. Placing Concrete In Cold Weather:

a. In temperatures below 40 degrees F, place concrete in accordance with ACI 306.1.

C. Consolidate concrete in accordance with ACI 301. If evidence of inadequate consolidation is observed, concrete placement will be suspended until Contractor provides a revised plan to achieve proper consolidation.

3.03 CURING AND SEALING

A. General:

1. Cure concrete using water (including form curing and use of moister retaining covers), a clear membrane curing compound, or by a combination of both methods. Coordinate repairs or treatment of concrete surfaces so that interruption of curing will not be necessary.

2. Maintain concrete surface temperature between 50 degrees F and 80 degrees F for at least 5 days. Cure concrete in hot weather (above 80 degrees F) in accordance with ACI 305.1. Cure concrete in cold weather (below 45 degrees F) in accordance with ACI 306.1.

B. Water Curing:

1. Keep concrete continuously wet for a minimum of 10-days after placement (14 days after placement for sections over 3-feet thick). Absorptive mats or fabric may be used to retain moisture during the curing period. Absorptive covers shall comply with AASHTO M182, Class 3, and moisture retaining covers shall comply with ASTM C171.

2. Use water curing in hot weather for liquid containment structures. Cover forms and keep moist. Loosen forms as soon as possible without damage to the concrete, and make provisions for curing water to run down inside them. During form removal, take care to provide continuously wet cover to newly exposed surfaces.

C. Curing Compound:

1. When curing compound is allowed, apply it as soon as the concrete has set sufficiently so as not to be marred by the application or apply it immediately following form removal for vertical and other formed surfaces. Preparation of surfaces, application procedures, and installation precautions shall follow manufacturer's instructions. For liquid containing structures, apply curing compound at twice the manufacturer's recommended dosage rate, applied in two coats perpendicular to each other.
2. Do not use curing compound on concrete surfaces to be coated, waterproofed, moisture-proofed, tiled, roofed, or where other coverings are to be bonded. In these cases, use water curing unless the curing compound is first removed or is compatible with the final finish covering.

3.04 PROTECTION

A. Protect concrete from injurious action by sun, rain, wind, flowing water, frost, excessive vibration and mechanical means.

B. Loading green concrete is not permitted. Green concrete is defined as concrete with less than 100 percent of the specified strength.

C. Backfill shall not be placed against concrete walls until the concrete has reached the specified strength, connecting slabs and beams have been cast and have also reached the specified strength, and watertightness testing and repairs have been completed for liquid containing structures to the satisfaction of the Owner's Representative.

D. Arrangements for covering, insulating, heating, and protecting concrete in cold weather shall be in accordance with ACI 306.1.

3.05 CONSTRUCTION JOINTS

A. General:

1. Place concrete in each unit of construction continuously. Before new concrete is placed on or against concrete which has set, retighten forms and clean foreign matter from the surface of the set concrete. Provide waterstops as specified.

B. Construction:

1. Form construction joints by producing a rough surface of exposed aggregates using a surface retardant (or water blasting method); include joints between the slab and topping concrete. The limit of the treated surfaces shall be 1 inch away from the joint edges. Within 24 hours after placing, remove retarded surface mortar either by high pressure water jetting or stiff brushing or combination of both so as to expose coarse aggregate. A rough surface of exposed aggregate may also be produced by sandblasting followed by high pressure water jetting. Sandblasting, if used, shall remove 1/4 inch of laitance film and expose coarse aggregate to ensure adequate bond and watertightness at the construction joints.
2. At contractor's option, submit alternate method of preparing construction joints to engineer for review.

C. Locations:

1. Provide construction joint locations as follows:
    a. Cast walls in panels not to exceed 50 feet in length. Cast adjoining panels only after 3-days have elapsed. Joints are not allowed within the lesser of 10 feet or 25 percent of the wall length from a corner unless specifically detailed thus on the drawings.
    b. Locate joints in beams or girders at or near the quarter point between supports.
    c. Make joints in the members of a floor system at or near the quarterpoint of the span.
    d. Make joints in walls and columns at the underside of floors, slabs, beams or girders and at the tops of footings or floor slabs.
    e. Cast slab panels in checkerboard patterns not to exceed 50 feet in length with maximum 1 ½ to 1 ratio of side lengths. Minimum lapsed time between placing adjacent panels shall be 3-days. The requirements for size of slab panel is waived if joints are located on the Drawings.
2. Continue reinforcing steel through construction joints. Beams, girders, and floor slabs shall not be constructed over columns or walls until at least 1 day has elapsed to allow for initial shrinkage in the column or wall. No joint will be allowed between a slab and a beam or girder unless otherwise shown. Joints shall be perpendicular to the main reinforcement. Provide waterstops in construction joints as specified.

3.06 INSERTS AND EMBEDMENTS

A. Inserts:

1. Where pipes, castings, or conduits are to pass through structures, position in forms before placing concrete; or where shown on Drawings or approved by the Owner's Representative, provide openings in the concrete for subsequent insertion of such pipes, castings, or conduits. Provide waterstops and a slight flare in the form to facilitate grouting and permit the escape of entrained air during grouting.
2. Provide additional reinforcement around openings. Use non-shrink grout to infill around inserts.
3. Place horizontal conduits and pipes, in slabs and beams, between the top and bottom layers of reinforcement. Spacing and size limitations shall conform to ACI 318.
4. Conduits and pipes shall not run directly beneath a column or base plate.
5. Position conduit, pipe, and other ferrous items such that there will be a minimum of 2-inches clearance between said item and concrete reinforcement. Welding inserts to reinforcement is not permitted.
6. The outside diameter of conduit or pipe shall not exceed one-fourth the slab or beam thickness.

B. Embedments:

1. Gate frames, gate thimbles, special castings, channels, grating frames, or other miscellaneous metal parts to be embedded in concrete shall be secured in the forms prior to concrete placement.
2. Embed anchor bolts and inserts in concrete as shown. Provide inserts, anchors, or other bolts necessary for the attachment of piping, valves, metal parts, and equipment.

3. Provide nailing blocks, plugs, strips, and the like necessary for the attachment of trim, finish, and similar work. Voids in sleeves, inserts, and anchor slots shall be filled temporarily with readily removable material to prevent entry of concrete. Do not use continuous anchor slots or strips in concrete intended to be watertight.
4. Position operators or sleeves for gate or valve stems to clear reinforcing steel, conduit, and other embedments, and to align accurately with equipment.

3.07 WATERSTOPS

A. Waterstops shall conform to ACI 301. Tie waterstops in position prior to placement of concrete to prevent movement and deformation.

B. Provide waterstops in construction and expansion joints as follows:
   1. Joints in parts of structures exposed to ground or water on one side and occupied by non-submerged equipment or by personnel on the other.
   2. Wall and slab joints of tanks and channels subject to water pressure.
   3. Waterstops shall be provided for the full height of the walls.
   4. Provide at other locations shown on the Drawings.

C. Field splices shall be at straight sections using heat fused welded, butt splices only. Lapping of splices or joining by means other than heat fused welding is not allowed.

D. Install hydrophilic waterstops according to manufacturer's recommendations. Surfaces of concrete shall be prepared level/plumb and to the smoothness required by manufacturer. Grind surface, as necessary. Provide bonding adhesive and concrete nails with fender washers to hold waterstop in position during concrete placement.

3.08 MODIFICATION OF EXISTING CONCRETE

A. General:
   1. Verify structural dimensions related to or controlled by previously constructed or existing structures prior to concrete work.

B. Cutting or Coring Concrete:
   1. Saw cut concrete to a depth of 1 inch to form straight outlines of concrete areas to be removed. Where reinforcement is exposed due to saw cutting or core drilling and no new material is to be placed on the cut surface, provide a protective epoxy coating to the entire cut surface.
   2. Coat surfaces of oversized openings with an epoxy bonding compound prior to re-finishing with profiling mortar to the required opening size.
   3. Grind existing joint edges to create a chamfer matching those used on adjacent construction.

4. Investigate concrete to be drilled, cored, or sawcut to determine location of reinforcing steel. Locate penetrations to clear existing reinforcing steel. Where not possible to avoid cutting thru one reinforcing steel every 48" on-center at slabs and walls, consult the Engineer as to acceptability of cutting reinforcing steel and provide new reinforcing systems as directed.
5. Locating methods include chipping to expose reinforcing steel, ground penetrating radar, X-ray, or magnetic flux devices. Locates of existing reinforcing shall be by the Contractor.

C. Joining New Concrete To Existing:
1. Existing concrete surfaces to be joined with new concrete shall be cleaned and roughened by abrasive blasting, bush hammering, or other method to achieve ¼-inch amplitude surface. Remove existing metalwork, embeds, or other interfering items. Coat existing surface with epoxy bonding compound prior to placement of new concrete.

D. Post-Installed Anchors and Dowels:
1. Use non-destructive methods for locating reinforcement prior to drilling operations. For anchor and dowel locations that interfere with reinforcement, attempt to relocate to avoid drilling through the reinforcement if possible.
2. For situations that do not allow relocation, cutting of reinforcement for installation is subject to the following:
    a. Prior to drilling through reinforcement, the Contractor shall consult the Owner's Representative or Engineer.
    b. Drill holes with a hammer drill and carbide bit (core drilled holes are not allowed), followed by brushing and air-cleaning with oil-free compressed air.
    c. Holes drilled through reinforcement must be in compliance with adhesive anchor assumptions for roughened hole surface typical of a hammer drill and carbide bit. No smooth hole surfaces are allowed.
    d. Do not cut slab rebar within 24 inches of a supporting wall, column, or an opening in the slab.
    e. No cutting of rebar is allowed in the middle third of slab spans for anchors with diameters equal to or greater than 3/4 inch.
    f. Maximum of two rebar may be cut in any 10 foot width of slab.
    g. Maximum of two rebar may be cut within any 10 foot width of concrete wall.
    h. Maximum of one rebar may be cut within any 8 foot width of CMU wall.
3. For anchors that cannot be moved and that conflict with the above requirements, consult Engineer for direction. It is not acceptable to cut reinforcement in beams, columns, precast members, or stairs.
4. Use a pre-manufactured, self-mixing, injectable, two-component, epoxy adhesive, as per Section 03 60 00. Follow manufacturer's recommendations and ICC Evaluation Report for installation.

E. Waterstops:
1. Where a waterstop between new and existing concrete is required, install a hydrophilic waterstop, or a retrofit waterstop where indicated on the design drawings for the specific location.

3.09 FORMED SURFACE FINISHES

A. Repair Of Surface Defects:
   1. Repair surface defects, including tie holes, minor honeycombing, or otherwise defective concrete in accordance with ACI 301. Clean areas to be repaired. Cut and chip out honeycombed or otherwise defective areas to solid concrete, to a depth of at least 1-inch. If defective area includes exposed reinforcing steel, correct by removing concrete a minimum of 1-inch beyond the reinforcing. Make edges of the cut perpendicular to the surface of the concrete in a neat rectangular pattern.
   2. Joints shall be grooved to a radius or bevel of ¾-inch depth.
   3. Finish patches on exposed surfaces to match and blend with adjoining work. Cure patches as specified for the concrete. Protect finished surfaces from stains and abrasions.

B. Formed Surface Finishes:
   1. Finish A - Grout Rubbed Finish:
      a. After repair of surface defects, apply a grout rubbed finish in accordance with ACI 301 except that all form fins and other protrusions shall be completely removed.
      b. Add a PVA bonding compound to the mix water used in sacking mortar; as recommended by the manufacturer.
      c. Provide Finish A at the following locations unless noted otherwise on the Drawings: uncoated surfaces of stair wells, at interior surfaces of equipment rooms, galleries, tunnels, operations areas, exposed channels and tanks from 1 foot below minimum water surfaces and up, at exposed exterior surfaces to 1 foot below grade, and at permanently exposed vertical and sloped surfaces such as pipe chases.
      d. Do not provide Finish A at concrete surfaces receiving a coating.
   2. Finish B - Smooth Surface Finish:
      a. Initial surface preparation is the same as Finish A; repair surface defects and remove all form fins.
      b. Provide Finish B at surfaces to be coated, at interior surfaces of exposed channels and tanks from 1 foot below minimum water surfaces and down (Finish A applied above this level), and full height at surfaces of wet wells, tanks, and channels not exposed to view. See Section 09 90 00 for additional concrete surface preparation, including filling of bug holes, and coating requirements.
   3. Finish C - Rough Form Finish:
      a. Repair surface defects and imperfections greater than 3/8 inch in any dimension. Remove form fins and protrusions down to less than 3/8 inch projection.
      b. Provide Finish C or smoother at exterior surfaces from 1 foot below grade and down, at other vertical surfaces not exposed to view and not specified above to receive Finish A or B.
      c. Also apply Finish C to unoccupied interior areas not otherwise specified.

4. Finish D – Unfinished Surface:
    a. Repair surface defects and otherwise leave the surfaces as they come from the forms, except plug tie holes and repair or remove defects greater than 1/2 inch in any dimension.

3.10 SLAB FINISHES

A. General:
    1. The finishes specified herein include surface finishes, treatments and toppings for floors and slabs. Do not use dry cement on new concrete surfaces to absorb excess moisture. Round edges to a radius of 1/2 inch.
    2. Slope floors to drain uniformly within a room or space. Unless otherwise specified, slope shall be a minimum of 1/8 inch per foot toward nearest drain. Restrict use of floor drains with only locally depressed slabs to locations specifically noted.
    3. Immediately after final finish is applied, the surface shall be cured and protected as specified in Curing, Sealing, and Protection paragraphs above.
    4. Where finish is not specified, floor slabs shall receive a Steel Trowel Finish.

B. Float Finish:
    1. Perform floating with a hand or power-driven float in accordance with ACI 301. Begin floating when the bleed water sheen has disappeared, and the surface has stiffened sufficiently. Float as required to meet tolerance requirements of ACI 117 for a conventional surface.
    2. Floating shall close cracks and checks plus compact and smooth the surface. Refloat the slab to a uniform texture.
    3. Apply float finish to surfaces of channels, tank bottom slabs, exterior below grade horizontal surfaces, including tops of footings, and surfaces to receive insulation or roofing.

C. Steel Trowel Finish:
    1. Float the concrete surface as indicated above and then trowel in accordance with ACI 301.
    2. Provide Steel Trowel Finish on interior exposed floors and slabs that will receive resilient flooring, carpet or ceramic tile, unless specified otherwise.

D. Broom Finish:
    1. Float the concrete surface as indicated above, then immediately give the concrete a coarse transverse scored texture by drawing a broom or burlap belt across the surface in accordance with ACI 301.
    2. Provide a Broom Finish for steps and ramps, exterior exposed horizontal surfaces, and where otherwise indicated.

E. Polished Concrete Finish:
   1. Concrete Polishing – The process of utilizing industrial diamonds to grind and polish a concrete surface with the application of a impregnating hardeners and sealers that will densify, polish and seal the floor. Process may be either a proprietary system from specialty contractor or use of specified products with acceptable grinding methods. Acceptable Grinding Methods include equipment and techniques that produce documented results of concrete finishes as defined by ASTM C1028 (wet surfaces) and ASTM D523 and ASTM E1155 requirements.
   2. Installer's Qualifications: Certified by International Polished Concrete Institute (IPCI).
   3. Materials:
      a. Concrete Densifier shall be clear odorless lithium silicate
      b. Concrete Sealer: Clear, highly concentrated, quick drying penetrating water and oil repellent sealer.
      c. Penetrating Dye: Ameripolish "Color Perfect colorants or approved equal. Color shall be selected by the Owner's Representative.
   4. Surface Examination and Preparation:
      a. Floor Finish: Steel trowel finish.
      b. Floor Surface Flatness Number (F_F): 50 (Preferred)– 45 (Min.).
      c. Floor Levelness Number (F_L): 35 (Preferred)– 30 (Min.).

F. Aggregate Exposure: Cream Aggregate (minimal to no course aggregate exposure).

G. Polished Concrete Floor System: IPCI Sheen Level 2 – Honed Finish. Achieve low sheen finish by grinding with 400 grit resin bonded diamonds.

H. Penetrating Dye: Apply penetrating dye.

I. Concrete Sealer: Apply concrete sealer.

J. Protection: Protect completed polished concrete floor system from damage until Substantial Completion.

3.11 RELATED SURFACES

A. Stair Treads:
   1. Construct stair treads with a nonskid nosing as specified in Section 05 50 00.
   2. Treads shall have a Float Finish followed by a Steel Trowel Finish with a slope of 1/8 inch toward the front.
   3. Ends of treads shall have a 1/16 to 1/8 inch cut between concrete and metal tread to allow for expansion.

B. Finishing of Unformed Surfaces:
   1. Adjacent Unformed Surfaces:
      a. Tops of walls, buttresses, horizontal offsets, and similar unformed surfaces occurring adjacent to formed surfaces shall be struck smooth after concrete is placed and shall be Float Finished to a texture reasonably consistent with that of the adjacent formed surface.
      b. Continue final treatment of formed surface uniformly across the top of the unformed surface.
   2. Pavements and Sidewalks:
      a. The surface of the concrete shall be screeded to grade and sloped to drain. After screeding, the surface shall be Float Finished followed by a Broom Finish.
      b. Round edges and expansion joints to a radius of 1/2 inch. Control joints shall be grooved or sawcut to a minimum depth of 1/4 the slab thickness.

3.12 FIELD SAMPLING AND TESTS

A. General:
   1. Field sampling and tests shall be performed by an independent testing laboratory. Samples of aggregates and concrete will be obtained at such times to represent the quality of the materials and work throughout the project.
   2. The laboratory shall provide necessary labor, materials and facilities for sampling aggregate and for casting, handling, and initially storing the concrete samples at the work site.
   3. The minimum number of samples and tests are specified in Testing paragraph below.

B. Sampling:
   1. Aggregates:
      a. General:
         1) Sample fine and coarse aggregates in accordance with ASTM D75 not less than 30 days prior to the use of such aggregates in the work.
         2) Take samples at the discharge gates of the bins feeding the weigh hopper. Repeat sampling when the source of material is changed or when unacceptable deficiencies or variations from the specified requirements of materials are found.
         3) Aggregate samples shall be tagged and their sources identified.
      b. Coarse Aggregate:
         1) Take a sample weighing between 50 and 60 pounds after the batch plant is brought up to full operation.
         2) Take samples to obtain a uniform cross section, accurately representing the materials on the belt or in the bins for sieve analysis.
      c. Fine Aggregate:
         1) Take samples as specified for coarse aggregate.
         2) Take samples of sand when the sand is moist for sieve analysis and specific gravity tests.

2. Concrete:
    a. Take samples of plastic concrete in accordance with ASTM C172.
    b. Take samples at the hopper of mixing equipment or transit mix truck, except as noted in the Placing Concrete by Pumping subparagraph of the Conveying and Placing article above.

C. Testing:
    1. Aggregate:
        a. A minimum of one test of coarse aggregate per 400 cubic yards of concrete used and a minimum of one test of fine aggregate per 200 cubic yards of concrete used shall be made to confirm continuing conformance with specifications for gradation, cleanliness and sand equivalent.
        b. A maximum of one test per week of each aggregate is required.
        c. Repeat of the entire concrete mix design test program is required before source changes will be accepted.

D. Concrete:
    1. Strength Tests:
        a. The strengths specified for the design mix shall be verified by the independent testing laboratory during placement of the concrete. Verification shall be accomplished by testing standard cylinders of concrete samples taken at the job site. Cylinders shall be 4 by 8 inch or 6 x 12 inch.
        b. Concrete samples shall represent the concrete placed in the forms. One set of six standard 6 x 12 inch (or nine 4 x 8 inch) cylinders shall be cast of each class of concrete for each 100 cubic yards or less, or for each 5,000 square feet of slab or wall surface area placed per day. Provide additional cylinders when an error in batching is suspected. Each set of cylinders are cast from material taken from a single load of concrete.
        c. Casting, handling and curing of cylinders shall be in accordance with ASTM C31. For the first 24 hours after casting, keep cylinders moist in a storage box constructed and located so that its interior air temperature will be between 60 and 80 degrees F. At the end of 24 hours, the testing laboratory will transport the cylinders to their laboratory.
        d. Testing of specimens for compressive strength shall be in accordance with ASTM C39. Each test shall consist of two 6 x 12 inch (or three 4 x 8 inch) test cylinders from each group of six (or nine) specimens. Test at the end of 7 days and at the end of 28 days. The remaining cylinders shall be tested at the end of 56 days if the 28-day strength reports below specification.
        e. A strength test shall consist of the average strength of two 6 x 12 inch (or three 4 x 8). If one cylinder shows evidence of low strength due to improper sampling, casting, handling, or curing, the result of the remaining cylinders may be used if approved by the Owner's Representative.
        f. The average of any three consecutive 28-day strength test results of the cylinders representing each class of concrete for each structure shall be equal to or greater than the specified strength. Not more than 10 percent of the individual strength test results shall have values less than the specified 28-day strength for the total job concrete. No individual strength test result shall be less than the specified strength by more than 500 pounds per square inch.

g. Provide certified reports of the test results directly to the Owner's Representative and the Engineer. Test reports shall include sufficient information to identify the mix used, the stationing or location of the concrete placement, and the quantity placed. Slump, water/cement ratio, air content, temperature of concrete, and ambient temperature shall be noted.

h. The 28-day strength test results shall be evaluated in accordance with ACI 214R. Quality control charts showing field test results shall be included with the test results for each class of concrete in each major structure. Charts shall be prepared in accordance with ACI 214R. Quality control charts shall be maintained throughout the entire project and shall be available for the Owner's Representative's inspection at any time.

i. If the 28-day test results fall below the specified compressive strength for the class of concrete required for any portion of the work, adjustment in the proportions, water content, or both, shall be made as necessary at the Contractor's expense. Report changes and adjustments in writing to the Owner's Representative.

j. If compressive test results indicate concrete in place may not meet structural requirements, tests shall be made to determine if the structure or portion thereof is structurally sound. Tests may include, but not be limited to, cores in accordance with ASTM C42 and any other analyses or load tests acceptable to the Engineer. Costs of such tests and/or analysis shall be borne by the Contractor.

2. Tests for Consistency of Concrete:

a. Measure slump in accordance with ASTM C143. Take samples for slump determination from concrete during placement. Tests shall be made at the beginning of concrete placement operation, whenever test cylinders are cast, and at subsequent intervals to ensure that the specification requirements are met.

b. For pumped concrete, measure slump in accordance with the Placing Concrete by Pumping subparagraph of the Conveying and Placing article above.

c. When high range water reducer is added at the site, slump tests shall be taken before and after addition of the admixture.

3. Tests for Temperature and Air Content:

a. Temperature tests shall be made at frequent intervals during hot or cold weather conditions until satisfactory temperature control is established. Perform temperature tests whenever test cylinders are cast.

b. Measure air content in accordance with ASTM C231 whenever test cylinders are cast. For pumped concrete, measure air content in accordance with the Placing Concrete by Pumping subparagraph of the Conveying and Placing article above.

E. Final Laboratory Report:

1. The testing laboratory shall provide a final report at the completion of all concreting. This report shall summarize the findings concerning concrete used in the project and provide totals of concrete used by class and structure.

2. Include final quality control charts for compressive strength tests for classes of concrete specified in each major structure. Also include the concrete batch plant's coefficient of variation and standard deviation results for each class of concrete.

3.13 REPAIR OF DAMAGED AND CRACKED CONCRETE

A. Acceptance Of Concrete:
   1. Completed cast-in-place concrete work shall conform to the applicable requirements of ACI 301 and the Contract Documents. Concrete work that fails to meet these requirements shall be repaired, as approved by the Engineer, to bring the concrete into compliance. Repair methods shall be in accordance with ACI standards, including ACI 503.7, and are subject to the approval of the Engineer.
   2. Concrete that cannot be brought into compliance by approved repair methods will be rejected. Remove and replace rejected concrete work.
   3. The cost of repairs and replacement of defective concrete shall be borne by the Contractor.

B. Repair Methods:
   1. Damaged/defective concrete or concrete with crack widths exceeding 0.004 inches at liquid-containing and conveying structures or crack widths exceeding 0.006 inches for other structures shall be repaired by one of the following methods (only the Engineer may determine that a defect or crack does not require repair):
      a. Perform watertightness testing and repair as needed to meet leakage criteria in this specification even when liquid-containing and conveying structures meet the crack width criteria defined above.
      b. Damaged or defective concrete includes surface defects, honeycomb, rock pockets, indentations greater than 3/16 inch, spalls, chips, air bubbles greater than 1/2 inch diameter, pinholes, bugholes, embedded debris, lift lines, sand lines, bleed lines, leakage from form joints, fins, projections, form popouts, texture irregularities, and stains or other color variation that cannot be removed by cleaning.
         1) Damaged or defective concrete is repaired according to procedures outlined above under finish requirements, Repair of Surface Defects.
   2. Crack Repair Method 1:
      a. Fill the joint or crack by drilling holes to the affected area (following the product manufacturer's details), install injection ports, and force epoxy or chemical grout (expanding urethane) into the joint under pressure.
      b. Material type and repair procedures shall be approved by Engineer.
      c. After injection and curing; ports, sealing mix, and surface shall be cleaned and worked to match the adjacent specified finish.
   3. Crack Repair Method 2:
      a. Fill cracks with low viscosity epoxy, applied by pouring/flooding crack zone until cracks are filled. Prepare surface, install, and cure according to manufacturer's recommendations.
      b. At a minimum, prepare surface to be clean and dry with no visible detrimental material in cracks to be filled. Conform to temperature limitations of epoxy. Clean and refinish to match adjacent surfaces.
   4. Crack Repair Method 3:
      a. Cut a bevel groove 3/8 to 1/2 inch in width and depth, use backer rod or tape, and fill with sealant in accordance with manufacturer's instructions.

b. This repair method is only used where approved by Engineer.

c. Groove and sealant shall be applied on wet or hydrostatic pressure side of surface.

C. Repair Method Use:

1. Repair Method 1: For cracks in walls, surfaces sloped 1:1 or greater, beams, columns, structural slabs, overhead surfaces, and liquid retaining surfaces. Need for repair depends upon crack width, location, and leakage.
2. Epoxy grout is used for repair of structural cracks and chemical grout (expanding urethane) for repair of non-structural cracks at liquid-containing structures. The Engineer shall determine whether a crack is classified as structural or non-structural.
3. Repair Method 2: Utilized in lieu of Method 1 for slabs when approved by Owner's Representative. Final finish shall match adjacent surfaces.
4. Repair Method 3: Limited to dry-surface slabs, walls subject to less than three feet of liquid pressure, or as approved by Engineer. Repair Method 3 is not an equivalent repair method to Repair Methods 1 or 2, which shall be considered the standards.

3.14 CLEANUP

A. Upon completion of the work and prior to final inspection, clean all concrete surfaces as follows: Sweep with a broom to remove loose dirt, then mop and/or flush with clean water.

B. Clean floors that have curing and sealing compound as stated above, followed by the final application of curing and sealing compound.

END OF SECTION

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SECTION 03 60 00

GROUTING

PART 1 GENERAL

1.01 DESCRIPTION

A. Section includes: Grout for column base plates, other structural supports, equipment bases, reinforcing bar dowels, surface repair, grout toppings, patching of fresh concrete, and uses other than masonry. Adhesive anchor bolt grouting is specified in Section 05 05 20. Topping concrete over precast elements and clarifier topping concrete is specified in Section 03 30 00.

1.02 RELATED SECTIONS

A. This section contains specific references to the following related sections. Additional related sections may apply that are not specifically listed below.
   1. Section 03 30 00 Cast-In-Place Concrete
   2. Section 04 22 00 Concrete Unit Masonry
   3. Section 05 05 20 Anchor Bolts
   4. Section 43 05 13 Rigid Equipment Mounts

1.03 REFERENCES:

A. The references listed below are a part of this section. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.

Reference	Title
ASTM C109	Test Method for Compressive Strength of Hydraulic Cement Mortars (Using 2 inch or 50 mm Cube Specimens)
ASTM C230	Flow Table for Use in Tests of Hydraulic Cement
ASTM C307	Standard Test Method for Tensile Strength of Chemical-Resistant Mortar, Grouts, and Monolithic Surfacings
ASTM C939	Test Method for Flow of Grout for Preplaced-Aggregate Concrete (Flow Cone Method)
ASTM C531	Standard Test Method for Linear Shrinkage and Coefficient of Thermal Expansion of Chemical-Resistant Mortars, Grouts, Monolithic Surfacings, and Polymer Concretes
ASTM C579	Standard Test Methods for Compressive Strength of Chemical-Resistant Mortars, Grouts, Monolithic Surfacings and Polymer Concretes
ASTM C882	Standard Test Method for Bond Strength of Epoxy-Resin Systems Used with Concrete by Slant Shear
ASTM C942	Standard Test Method for Compressive Strength of Grouts for Preplaced-Aggregate Concrete in the Laboratory
ASTM C1107	Packaged Dry, Hydraulic-Cement Grout (Non-shrink)

Reference	Title
ASTM C1181	Standard Test Methods for Compressive Creep of Chemical-Resistant Polymer Machinery Grouts
ASTM E329	Agencies Engaged in Construction Inspection, Testing, or Special Inspection
COE CRD-C611	Flow of Grout for Preplaced Aggregate Concrete
COE CRD-C621	Non-shrink Grout
IBC	International Building Code

1.04 SUBMITTALS

A. Action Submittals

1. Procedure: Section 01 33 00:
2. A copy of this specification section with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements.
3. Check-marks (✓) shall denote full compliance with a paragraph as a whole. Deviations shall be underlined and denoted by a number in the margin to the right of the identified paragraph. The remaining portions of the paragraph not underlined will signify compliance on the part of the Contractor with the specifications. Include a detailed, written justification for each deviation. Failure to include a copy of the marked-up specification sections, along with justification(s) for any requested deviations to the specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration.
4. Complete product literature, including mixing, handling and placement instructions for the following: Cementitious non-shrink grout, epoxy grout, adhesive for reinforcing bar dowel grouting, concrete repair mortar, and prepackaged cement grout products to be used on the project.
5. Mix design for cement grout that is not prepackaged, including product data for aggregates and cement in accordance with Section 03 30 00.
6. Current ICC Evaluation Service reports for adhesives used for reinforcing dowels.
7. Installer certification in accordance with ACI/CRSI Adhesive Anchor Installer Certification Program for installers of horizontal or upwardly inclined reinforcing bar dowels grouted using adhesive.
8. Certified test results verifying the compressive strength, shrinkage and expansion requirements specified herein.

1.05 QUALITY ASSURANCE

A. Quality Control by Owner

1. The Owner will provide the services of a qualified Special Inspector in accordance with Section 01 45 23.

2. Adhesive anchors installed in horizontal or upwardly inclined orientations to resist sustained tension loads shall be continuously inspected during installation by a Special Inspector.
    a. The Special Inspector shall furnish a report to the Engineer, Owner's Representative and Building Official that the work covered by the report has been performed and that the materials used and the installation procedures used conform with the approved Project Manual and the Manufacturer's Printed Installation Instructions (MPII).

B. Quality Control by Contractor
    1. Provide the services of an independent testing laboratory which complies with the requirements of ASTM E329 if a product other than those listed below is proposed and test data is not available from the supplier to demonstrate equivalence to the specified grout. The testing laboratory shall sample and test the proposed grout materials. Costs of testing laboratory services shall be borne by the Contractor.

C. Certifications
    1. Installer certification shall be in accordance with ACI/CRSI Adhesive Anchor Installer Certification Program for installers of horizontal or upwardly inclined reinforcing bar dowels grouted using adhesive.

D. Compression test specimens will be taken during construction from the first placement of each type of grout and at intervals thereafter as selected by the Engineer to insure continued compliance with these Specifications.
    1. Compression tests and fabrication of specimens for epoxy grout will be performed as specified in ASTM C579, Method B, at intervals during construction as selected by the Engineer. A set of three specimens will be made for testing at seven days and any other time period as appropriate.
    2. Compression tests and fabrication of specimens for cement grout and non-shrink grout will be performed as specified in ASTM C109 at intervals during construction as selected by the Engineer. A set of three specimens will be made for testing at seven days, 28 days and any additional time period as appropriate.

E. Manufacturer Qualifications
    1. Manufacturer shall have a minimum of five years experience of producing products substantially similar to that required and shall be able to submit documentation of at least five satisfactory installations that have been in successful operation for at least five years each.
    2. When required, provide services of manufacturer's full-time employee, factory-trained in handling, use, and installing the products required, with at least five years of experience in field applications of the products required.

PART 2 PRODUCTS

2.01 CEMENTITIOUS NON-SHRINK GROUT

A. The grout material shall be an approved ready to use mixture requiring only water for use at the job site. The 2-inch cubes shall have a minimum compressive strength of 3,000 psi at 7 days and 7,000 psi at 28 days.

B. Cementitious non-shrink non-metallic aggregate grout shall be:
   1. BASF, Masterflow 928
   2. Euclid Chemical Company, Hi-Flow Grout
   3. Five Star Products, Inc., Five Star Grout
   4. Sika Corporation, SikaGrout 212
   5. Approved Equal

C. Non-shrink grout shall conform to CRD-C 621 and ASTM C1107, Grade B or C when tested at a maximum fluid consistency of 30 seconds per ASTM C939 at temperature extremes of 45 degrees Fahrenheit and 90 degrees Fahrenheit and an extended working time of 15 minutes.

D. Fluid grout shall pass through the flow cone, with continuous flow, one hour after mixing.

2.02 ADHESIVE FOR GROUTING REINFORCING BAR DOWELS

A. Adhesive for setting dowels in concrete shall be an injectable two-component epoxy adhesive. Adhesive shall be approved for the intended use per the product ICC Report. Adhesive shall be:
   1. Hilti, HIT-RE 500v3
   2. Simpson Strong Tie, SET XP
   3. Approved Equal (equivalent product must have ICC approval for use in cracked concrete in areas with high seismic risk).

B. Adhesive for setting dowels in concrete masonry shall be an injectable two-component epoxy adhesive. Adhesive shall be approved for the intended use per the product ICC Report or IAPMO Report. Adhesive shall be:
   1. Hilti, HIT-HY 70
   2. Simpson Strong Tie, SET XP
   3. Approved Equal acceptable per ICC Report or IAPMO Report for resisting earthquake loads.

2.03 CONCRETE REPAIR MORTAR

A. Horizontal Applications: Repair mortars shall be:
   1. BASF, MasterEmaco S 466CI
   2. Sika Corporation, SikaTop 111 Plus
   3. Approved Equal

B. Vertical and Overhead Applications: Repair mortars shall be:
   1. BASF, MasterEmaco 1500HCR Vertical Overhead
   2. Sika Corporation, SikaTop 123 Plus
   3. Approved Equal

2.04 CEMENT GROUT

A. Cement grout shall be comprised of cement, fine aggregate, coarse aggregate, water, and admixtures proportioned and mixed in accordance with this Section.
   1. Minimum Compressive Strength: 4,500 psi at 28 days.
   2. Maximum Water Cement Ratio: 0.42 by weight.
   3. Coarse Aggregate: ASTM C33/C33M, No. 8 size.
   4. Fine Aggregate: ASTM C33/C33M, approximately 60 percent by weight of total aggregate.
   5. Air Content: Five percent (plus or minus one percent).
   6. Minimum Cement Content: 564 pounds per cubic yard.
   7. Slump for grout fill shall be adjusted to match placing and finishing conditions, and shall not exceed four inches.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine and accept existing conditions before beginning work.

3.02 CEMENTITIOUS NONSHRINK GROUT

A. Non-shrink, cementitious, nonmetallic aggregate grout shall be used for column base plates, structural bearing plates, and all locations where the general term “non-shrink grout” is indicated on the Drawings. Use of this grout to support the bearing surfaces of machinery shall be as specified in Section 43 05 13 or as detailed on the Drawings for specific locations or pieces of equipment. If guidance is not provided in locations noted above, use of non-shrink grout for equipment mounting shall be limited to equipment less than 25 horsepower or 750 pounds. Grout shall be placed and cured in accordance with the manufacturer's instructions.

B. Non-shrink cementitious grout shall not be used as a surface patch or topping. Non-shrink cementitious grout must be used in confined applications only.

3.03 EPOXY GROUT FOR EQUIPMENT MOUNTING

A. Prepare concrete surfaces of equipment pads as indicated in details on the Drawings and as required by the epoxy grout manufacturer. Epoxy grout for equipment mounting shall be placed and cured in accordance with the requirements of Section 43 05 13, details on the Drawings, and in conformance with manufacturer’s recommendations.

3.04 ADHESIVE FOR GROUTING REINFORCING BAR DOWELS

A. Follow manufacturer’s instructions.

3.05 CONCRETE REPAIR MORTAR

A. Concrete repair materials and procedures shall be submitted for review to the Owner’s Representative and shall be accepted prior to commencement of the repair work.

B. Follow all manufacturer's instructions, including those for minimum and maximum application thickness, surface preparation and curing. Add aggregate as required per manufacturer's recommendations. Any deviations from the manufacturer's instructions shall be submitted for review to the Owner’s Representative and shall be accepted prior to commencement of the work.

3.06 CEMENT GROUT

A. Cement grout shall be used for grout toppings less than four inches thick and for patching of fresh concrete.

B. Grouting shall comply with temperature and weather limitations in Section 03 30 00, Cast-In-Place Concrete.

C. Cure grout in accordance with grout manufacturer’s instructions for prepackaged grout and Section 03 30 00, Cast-In-Place Concrete, for non-prepackaged cement grout.

END OF SECTION

SECTION 05 05 14

HOT-DIP GALVANIZING

PART 1 GENERAL

1.01 DESCRIPTION

A. Section includes: Hot-dip galvanizing of steel materials.

1.02 RELATED SECTIONS

A. This section contains specific references to the following related sections. Additional related sections may apply that are not specifically listed below.
   1. Section 09 90 00

1.03 REFERENCES STANDARDS:

A. This Section contains references to the documents listed below. Those documents are a part of this Section as specified and modified. In the event of conflict between the requirements of this Section and those of the listed documents, the requirements of this Section shall prevail.

B. Unless otherwise specified, references to documents shall mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid (or on the effective date of the Agreement if there was no Bids). If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued. Where document dates are given in the following listing, references to those documents shall mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, discontinued or replaced. In all cases, the effective version of the local building code at the time of Advertisement for Bids or Invitation to Bid shall be considered the building code in effect.

C. ASTM A123/A123M - Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products; 2017.

D. ASTM A143/A143M - Standard Practice for Safeguarding Against Embrittlement of Hot-Dip Galvanized Structural Steel Products and Procedure for Detecting Embrittlement; Current Edition.

E. ASTM A153/A153M - Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware; 2023.

F. ASTM A384/A384M - Standard Practice for Safeguarding Against Warpage and Distortion During Hot-Dip Galvanizing of Steel Assemblies; Current Edition.

G. ASTM A385/A385M - Standard Practice for Providing High-Quality Zinc Coatings (Hot-Dip); Current Edition.

H. ASTM A780/A780M - Standard Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings; 2020.

I. ASTM B6 - Standard Specification for Zinc; Current Edition.

J. ASTM D6386 - Standard Practice for Preparation of Zinc (Hot-Dip Galvanized) Coated Iron and Steel Product and Hardware Surfaces for Painting; Current Edition.

K. ASTM E536 - Standard Test Methods for Chemical Analysis of Zinc and Zinc Alloys; Current Edition.

L. DOD-P-21035A - Paint, High Zinc Dust Content, Galvanizing Repair; Current Edition.

1.04 SUBMITTALS

A. Action Submittals
   1. Procedures: Section 01 33 00
   2. A copy of this specification section, and those listed below with addendum updates included, with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements. Checkmarks (✓) shall denote full compliance with a paragraph as a whole. Deviations shall be underlined and denoted by a number in the margin to the right of the identified paragraph. The remaining portions of the paragraph not underlined will signify compliance on the part of the Contractor with the specifications. Include a detailed, written justification for each deviation. Failure to include a copy of the marked-up specification sections, along with justification(s) for any requested deviations to the specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration.
   3. Coating applicator's Certificate of Compliance that the hot-dip galvanized coating meets or exceeds the specified requirements of ASTM A123/A123M or ASTM A153/A153M, as applicable.
   4. Evidence that the galvanized coating applicator is a member of the American Galvanizing Association.

1.05 QUALITY ASSURANCE

A. Hot-dip galvanized coating applicator shall be a member of the American Galvanizing Association.

PART 2 PRODUCTS

2.01 MATERIALS

A. Zinc used for galvanizing shall conform to ASTM B6 and shall be at least equal to the grade designated as Prime Western.

B. Maximum amount of aluminum added to a galvanizing bath shall not exceed 0.01 percent.

C. Hot-Dip Galvanized Coating: Conform to ASTM A123/A123M and ASTM A153/A153M, as applicable.

D. Repair: Zinc dust-zinc oxide coating conforming to MIL-P-21035B and achieving 93 percent zinc in the dry film. Acceptable products:
   1. ZRC Cold Galvanizing Compound by ZRC Worldwide
   2. 1000 System Cold Galvanizing Compound by Rustoleum
   3. Crown Cold Galvanize Coating 93% Zinc Rich by Aervoe Industries
   4. or approved equal.

2.02 FABRICATION REQUIREMENTS

A. Fabrication practices for products to be galvanized: In accordance with applicable portions of ASTM A143/A143M, ASTM A384/A384M and ASTM A385/A385M. Avoid fabrication techniques that could cause steel distortion or embrittlement.

B. Coordinate with steel detailer to provide vent and drain holes of sufficient size and quantity to achieve specified galvanized coating.

PART 3 EXECUTION

3.01 PREPARATION

A. Casting surfaces to be galvanized shall be sand blasted or ground smooth. When a smooth cast is required, castings shall be tumbled and all high spots ground flush. Castings shall be normalized to prevent cracking. Malleable iron shall be safeguarded against embrittlement by pre-annealing.

B. Steel work shall be precleaned utilizing a caustic bath, acid pickle and flux or shall be blast cleaned and fluxed to obtain an acceptable surface for quality hot dip galvanizing.

3.02 APPLICATION

A. Steel Members, Fabrications, and Assemblies: Hot-dip galvanize after fabrication in accordance with ASTM A123/A123M.

B. Steel Bolts, Screws, Nuts, Washers and Hardware Components: Hot-dip galvanize in accordance with ASTM A153/A153M.

3.03 COATING REQUIREMENTS

A. Hot-dip Coating Thickness: Conform to ASTM A123/A123M or ASTM A153/A153M, as applicable.

3.04 TESTING

A. Chemical analysis for impurities in the bath shall be made in conformity with ASTM E536.

B. Test Requirements and Methods: In accordance with ASTM A123/A123M or ASTM A153/A153M, as applicable.

3.05 GALVANIZED SURFACES TO BE PAINTED

A. Where galvanized surfaces are specified to be painted in Section 09 90 00 or elsewhere in the Project Manual, conform to ASTM D6386.

3.06 REPAIR OF DEFECTIVE GALVANIZED COATING

A. Where zinc coating has been damaged after installation, clean substrate surface and repair with zinc dust-zinc oxide coating in accordance with ASTM A780/A780M. Apply zinc dust-zinc oxide coating in accordance with manufacturer's recommendation. Apply multiple coats to achieve a minimum film thickness of 8 mils.

B. Remove items not physically damaged, but which have insufficient or deteriorating zinc coatings, and items damaged in shipment or prior to installation, from the project site for repair by the hot-dip zinc coating method.

END OF SECTION

SECTION 05 05 20

ANCHOR BOLTS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Bolts and all-thread rods used to attach structural elements and equipment to concrete and concrete masonry. Included are cast-in-place and post-installed anchors (adhesive systems and wedge type expansion anchors), nuts and washers.

B. Cast-in-place and post-installed anchors shall be Type 316 stainless steel unless noted otherwise.

1.01 RELATED SECTIONS

A. This section contains specific references to the following related sections. Additional related sections may apply that are not specifically listed below.

1. Section 01 73 24 Design Requirements for Nonstructural Components and Nonbuilding Structures
2. Section 03 30 00 Cast-In-Place Concrete
3. Section 03 60 00 Grouting
4. Section 43 05 13 Rigid Equipment Mounts

1.02 REFERENCES

A. The references listed below are a part of this section. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.

Reference	Title
ACI 318	Building Code Requirements for Structural Concrete
ASTM A193	Alloy-Steel and Stainless Steel Bolting for High Temperature or High Pressure Service and Other Special Purpose Applications
ASTM A194	Carbon and Alloy Steel Nuts for Bolts for High Pressure or High Temperature Service, or Both
ASTM A320	Alloy-Steel and Stainless Steel Bolting for Low-Temperature Service
ASTM A563	Carbon and Alloy Steel Nuts
ASTM F593	Stainless Steel Bolts, Hex Cap Screws, and Studs
ASTM F594	Stainless Steel Nuts
ASTM F844	Washers, Steel, Plain (Flat), Unhardened for General Use
ASTM F1554	Anchor Bolts, Steel, 36, 55, 105-ksi Yield Strength
IBC	International Building Code with local amendments

1.03 SUBMITTALS

A. Action Submittals
   1. Procedures: Section 01 33 00.
   2. A copy of this specification section with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements.
   3. Check-marks (✓) shall denote full compliance with a paragraph as a whole. Deviations shall be underlined and denoted by a number in the margin to the right of the identified paragraph. The remaining portions of the paragraph not underlined will signify compliance on the part of the Contractor with the specifications. Include a detailed, written justification for each deviation. Failure to include a copy of the marked-up specification sections, along with justification(s) for any requested deviations to the specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration.
   4. Anchor bolt placement plans.
   5. Anchor bolt, nut, and washer material information, including material certifications.
   6. Record copy of design calculations and details showing the required diameter, length, embedment, edge distance, confinement, anchor reinforcement, anchor bolt sleeves, connection redesign, and other conditions, stamped and signed by a Professional Engineer currently registered in the state of Washington. Calculations shall comply with the provisions of ACI 318-14, Chapter 17. Base anchor capacity determination on cracked concrete condition and compressive strength of new concrete per Section 03 30 00. Assume compressive strength of existing concrete is 3,000psi unless otherwise noted.
   7. Submit record copy of proof loading test results within five days after test.
   8. Product Data:
      a. ICC Evaluation Service Reports for post-installed adhesive type anchors and expansion (wedge type) anchors when allowed. Products shall be ICC approved for use in cracked concrete in high seismic areas (Seismic Design Category D, E and F).
      b. Product data indicating load capacity charts/calculations.
      c. Chemical resistance.
      d. Temperature limitations.
      e. Manufacturers written installation instructions.
   9. Installer certification for horizontal or upwardly inclined adhesive anchors in accordance with ACI/CRSI Adhesive Anchor Installer Certification Program.

1.04 QUALITY ASSURANCE

A. Quality Assurance By Owner
   1. Special inspection of anchor bolts shall be performed by the Special Inspector under contract with the Owner and in accordance with IBC Chapter 17.
   2. A five percent sample of installed post-installed anchors shall be proof-loaded by an independent laboratory contracted by the Contractor. The quantity of samples and locations shall be coordinated with the Owner's Representative.

3. Adhesive anchors installed in horizontal or upwardly inclined orientations to resist sustained tension loads shall be continuously inspected during installation by a Special Inspector.
4. The Special Inspector shall furnish a report to the Engineer, Owner's Representative, and Building Official that the work covered by the report has been performed and that the materials used and the installation procedures used conform with the approved Project Manual and the Manufacturer's Printed Installation Instructions (MPII).

B. Certifications
1. Installer certification shall be in accordance with ACI/CRSI Adhesive Anchor Installer Certification Program for installers of horizontal or upwardly inclined adhesive anchors.

PART 2 PRODUCTS

2.01 GENERAL

A. Anchor bolt holes in equipment support frames shall not exceed the bolt diameters by more than 1/4 inch. Minimum anchor bolt diameter shall be 1/2 inch.

B. Tapered washers shall be provided where mating surface is not square with the nut.

C. Anchor bolts shall be cast-in-place anchors unless post-installed anchors are specified or shown on the Drawings. Substitution of post-installed anchors will not be permitted unless specifically requested by the Contractor and approved by the Engineer.

2.02 PERFORMANCE/DESIGN CRITERIA

A. Anchor bolts for equipment shall be designed by the equipment manufacturer to include equipment operational loads combined with seismic and wind forces when applicable. Design criteria provided in Section 01 73 24.

B. Design anchor bolts for support and bracing of non-structural components and non-building structures for loading specified in Section 01 73 24.

2.03 MATERIALS

A. Anchor bolt materials shall be as specified in the following table:

Material	Specification
Stainless Steel Anchor Bolts	ASTM A193 or A320, Type 316
Stainless Steel Threaded Rods	ASTM F593, Type 316
Stainless Steel Nuts	ASTM A194 Heavy Hex Nuts, Type 316 ASTM F594 Heavy Hex Nuts at Adhesive Anchors, Type 316
Stainless Steel Washers	Type 316 to match bolt material
Carbon Steel Anchor Bolts	ASTM F1554, Grade 36, Hot Dip Galvanized
High-Strength Carbon Steel Anchor Bolts	ASTM F1554, Grade 55, Weldable per Supplementary Requirement S1, Hot Dip Galvanized
Carbon Steel Nuts and Washers	ASTM A563 and F844, Heavy Hex, Hot-Dip Galvanized

Material	Specification
Concrete Adhesive Anchors	Hilti “HIT-RE 500v3”, Simpson Strong-Tie “SET-XP”, or approved equal, with Type 316 Stainless Steel threaded rods
Concrete Masonry Adhesive Anchors	Hilti "HIT-HY 70", Simpson Strong-Tie “SET-XP”, or approved equal, with Type 316 Stainless Steel threaded rods
Concrete Masonry Expansion (wedge) Anchors*	Hilti "KWIK BOLT 3", or approved equal, Type 316 Stainless Steel
Concrete Expansion (wedge) Anchors *	Hilti “KWIK BOLT TZ”, or approved equal, Type 316 Stainless Steel

**Post installed anchors shall always be an adhesive type anchor system except where noted otherwise or when Contractor makes a request for a specific application and Engineer approves.*

2.04 STAINLESS STEEL FASTENER LUBRICANT (ANTI-SEIZING)

A. Anti-seizing Lubricant for Stainless Steel Threaded Connections:
   1. Formulated to resist washout.
   2. Acceptable manufacturers are Bostik, Saf-T-Eze, or equal.

PART 3 EXECUTION

3.01 GENERAL

A. Anchor bolts shall be cast-in-place anchors unless post-installed anchors are specified or shown on the Drawings.

B. Grouting of anchor bolts using plastic sleeves with non-shrink or epoxy grout, where specified, shall be in accordance with Section 03 60 00.

C. The threaded end of anchor bolts and all-thread rods shall be long enough to project through the entire depth of the nut and if too long, shall be cut off at ½-inch beyond top of nut and ground smooth.

3.02 CAST-IN-PLACE ANCHOR BOLTS

A. Anchor bolts to be embedded in concrete shall be placed accurately and held in correct position using templates while the concrete is placed.

B. After anchor bolts have been embedded, their threads shall be protected by grease and the nuts run on.

3.03 ADHESIVE ANCHOR BOLTS

A. Note that adhesive anchors shall not be substituted for cast-in-place anchor bolts unless the adhesive anchors have been specified or shown on the Drawings, or approval has been obtained from the Engineer that substitution of adhesive anchors is acceptable for the specific use and location. Use of adhesive anchors shall be subject to the following conditions:
   1. Limit to locations where intermittent or continuous exposure to the following is extremely unlikely:
      a. Acid concentrations higher than 10 percent
      b. Chlorine gas
      c. Machine or diesel oils
   2. Limit to applications where exposure to the following is extremely unlikely:
      a. Fire
      b. Concrete or rod temperature above 120 degrees F
   3. Overhead applications (such as pipe supports) shall not be allowed unless approved by the Engineer and installation is by an Installer specially certified for overhead applications.
   4. Approval from Engineer for specific application and from supplier of equipment to be anchored, if applicable.
   5. Anchor diameter and material shall be per Contract Documents or equipment manufacturer's specifications. Anchor shall be threaded or deformed the full length of embedment and shall be free of rust, scale, grease, and oils.
   6. Embedment depth shall be as specified or as required by the equipment manufacturer.
   7. Follow the anchor system manufacturer's installation instructions.
   8. Holes shall have rough surfaces created by using a hammer drill with carbide bit. Core drilled holes are not allowed.
   9. Holes shall be blown clean with oil-free compressed air and be free of dust or standing water prior to installation. Follow additional requirements of the adhesive manufacturer.
   10. Concrete and air temperature shall be compatible with curing requirements of adhesives per adhesive manufacturer's instructions. Anchors shall not be placed in concrete when the temperature is below 25 degrees F.
   11. Anchors shall be left undisturbed and unloaded for full adhesive curing period, which is based on temperature of the concrete.

3.04 EXPANSION ANCHORS

A. Expansion (wedge type) anchors shall not be substituted for cast-in-place anchor bolts or adhesive anchors unless approved by the Engineer for a specific application. Use of expansion anchors shall be subject to conditions 4 through 9 as specified above for adhesive anchors. Expansion anchors shall not be used in a submerged condition or in mounting of equipment subject to vibration or cyclic motion.

3.05 REINFORCING STEEL CONFLICTS WITH POST-INSTALLED ANCHOR INSTALLATION

A. When reinforcing steel is encountered in the drill path, slant drill to clear obstruction and provide beveled washer to match angle of anchor. Drill shall not be slanted more than 10 degrees.

B. Where slanting the drill does not resolve the conflict, notify the Owner's Representative and resolve the conflict to the satisfaction of the Owner's Representative in consultation with the Engineer.

C. Abandoned post-installed anchor holes shall be cleaned and filled with non-shrink grout and struck off flush with adjacent surface.

D. The costs of determining and executing the resolution shall be borne by the Contractor. The determination and execution of the resolution shall not result in additional cost to the Owner.

E. Reinforcing steel in masonry shall not be damaged.

F. In order to avoid or resolve a conflict, locate embedded reinforcing steel using non-destructive methods and/or redesign the attachment.
   1. Redesign shall be done by the Contractor's Professional Engineer currently registered in the state of Washington.
   2. Calculations and details for redesign shall be submitted.

END OF SECTION

SECTION 05 10 00

STRUCTURAL METAL FRAMING

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Structural metals consisting of standard shapes, hollow sections, fasteners, and plates that are used in structural framing and connections.

1.02 RELATED SECTIONS

A. This section contains specific references to the following related sections. Additional related sections may apply that are not specifically listed below.
   1. Section 01 33 00 Submittal Procedures
   2. Section 05 05 20 Anchor Bolts
   3. Section 05 05 14 Hot Dip Galvanizing
   4. Section 09 90 00 Painting

1.03 REFERENCES

A. The references listed below are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.

B. The references listed below indicate those documents in effect at the time of Advertisement for Bids, Invitation to Bid, or on the effective date of the Agreement if there were no Bids. Where documents are referenced in applicable local, state, or federal codes, use the version reference by date in the individual code. If referenced documents are not specifically identified in the applicable code(s), reference to those documents shall indicate the latest version of the documents available at the time of Advertisement for Bids. If referenced documents have been discontinued by the issuing organization, reference to those documents shall mean the latest version of replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued. When document dates are given in the following listing that are not specifically referenced in an applicable code, references to those documents shall mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, discontinued or replaced. For questions, refer to Engineer.

Reference	Title
Aluminum Association ADM	Aluminum Design Manual
AISC 207	Certification Programs
AISC 303	Code of Standard Practice for Steel Buildings and Bridges

Reference	Title
AISC 313	Code of Standard Practice for Structural Stainless Steel Buildings
AISC 325	Steel Construction Manual
AISC 341	Seismic Provisions for Structural Steel Buildings
AISC 358	Prequalified Connections for Special and Intermediate Steel Moment Frames for Seismic Applications
AISC 360	Specification for Structural Steel Buildings
AISC 370	Specification for Structural Stainless Steel Buildings
AISC DG 10	Erection Bracing of Low-Rise Structural Steel Buildings
AISC DG 27	Structural Stainless Steel
ASTM A6	General Requirements for Rolled Structural Steel Bars, Plates, Shapes, and Sheet Piling
ASTM A36	Carbon Structural Steel
ASTM A53	Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
ASTM A193	Alloy-Steel and Stainless Steel Bolting for High Temperature or High Pressure Service and Other Special Purpose Applications
ASTM A194	Carbon Steel, Alloy Steel, and Stainless Steel Nuts for Bolts for High Pressure or High Temperature Service, or Both
ASTM A276	Stainless Steel Bars and Shapes
ASTM A312	Seamless, Welded, and Heavily Cold Worked Austenitic Stainless Steel Pipes
ASTM A320	Alloy-Steel and Stainless Steel Bolting for Low Temperature Service
ASTM A380	Cleaning, Descaling, and Passivation of Stainless Steel Parts, Equipment, and Systems
ASTM A384	Safeguarding Against Warpage and Distortion During Hot-Dip Galvanizing of Steel Assemblies
ASTM A480	General Requirements for Flat-Rolled Stainless and Heat-Resisting Steel Plate, Sheet, and Strip
ASTM A484	General Requirements for Stainless Steel Bars, Billets, and Forgings
ASTM A500	Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes
ASTM A554	Welded Stainless Steel Mechanical Tubing
ASTM A529	High-Strength Carbon Manganese Steel of Structural Quality
ASTM A563	Carbon and Alloy Steel Nuts
ASTM A572	High-Strength Low-Alloy Columbium-Vanadium Structural Steel
ASTM A999	General Requirement for Alloy and Stainless Steel Pipe
ASTM A992	Structural Steel Shapes
ASTM A1069	Laser and Laser Hybrid Welded Stainless Steel Bars, Plates, and Shapes
ASTM B209	Aluminum and Aluminum-Alloy Sheet and Plate
ASTM B241	Aluminum and Aluminum-Alloy Seamless Pipe and Seamless Extruded Tube
ASTM B308	Aluminum-Alloy 6061-T6 Standard Structural Profiles
ASTM F3125	High Strength Structural Bolts and Assemblies, Steel and Alloy Steel, Heat Treated, Inch Dimensions 120 ksi and 150 ksi Minimum Tensile Strength, and Metric Dimensions 830 MPa and 1040 MPa Minimum Tensile Strength
ASTM F436	Hardened Steel Washers Inch and Metric Dimensions
ASTM F593	Stainless Steel Bolts, Hex Cap Screws, and Studs
ASTM F594	Stainless Steel Nuts
AWS-B2.1	Welding Procedure and Performance Qualification
AWS D1.1	Structural Welding Code – Steel
AWS D1.2	Structural Welding Code – Aluminum

Reference	Title
AWS D1.6	Structural Welding Code – Stainless Steel
AWS D1.8	Structural Welding Code – Seismic Supplement
RCSC	Structural Joints Using High Strength Bolts
IBC	International Building Code with local amendments
Local Code	Local building code if differs from IBC

1.04 SUBMITTALS

A. Action Submittals:

1. Procedures: Section 01 33 00.
2. A copy of this specification section with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements.
3. Check-marks (✓) shall denote full compliance with a paragraph as a whole. Deviations shall be underlined and denoted by a number in the margin to the right of the identified paragraph. The remaining portions of the paragraph not underlined will signify compliance on the part of the Contractor with the specifications. Include a detailed, written justification for each deviation. Failure to include a copy of the marked-up specification sections, along with justification(s) for any requested deviations to the specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration.
4. Shop drawings for approval prior to fabrication. Shop drawings shall not be reproductions of the Drawings. Include complete information for the fabrication and erection of the structure's components, including the location, type, and size of bolts, welds, member sizes and lengths, coatings, connection details, blocks, copes, and cuts. Substitutions of details shown on the Drawings shall be clearly highlighted on the fabrication drawings. Explain the reasons for any deviations from the Drawings.
5. Certification that steel Fabricator is approved to perform steel fabrication without special inspection.
6. AISC quality certification: Evidence that steel Fabricator has AISC 207 Certification as a AISC Certified Plant, Category BU (Certified Building Fabricator). Certificate to show name and address of certified firm, effective date, and category of certification.
7. Welding procedures, qualifications, and inspection report.
8. Certified mill test reports for structural steel and high-strength bolts and nuts.
9. In accordance with IBC Chapter 17, Fabricator at the completion of fabrication to submit Certification of Compliance stating that the fabrication was performed in accordance with the design documents.
10. Certified copies of all surveys conducted by a registered professional engineer or surveyor showing elevations and locations of base plates and anchor bolts to receive structural steel or aluminum, and final elevations and locations for major members. Indicate discrepancies between actual installation and contract documents.

1.05 QUALITY ASSURANCE

A. Quality Control by Owner:
   1. Special Inspection of structural metals work shall be performed by the Special Inspector under contract with the Owner and in conformance with the IBC Chapter 17. Special Inspector(s) and laboratory shall be acceptable to the Owner in their sole discretion. Special Inspection of structural metals is in addition to, but not replacing, other inspections and quality control requirements herein. Where sampling and testing required herein conforms to Special Inspection standards, such sampling and testing need not be duplicated.
   2. All structural steel work shall receive Special Inspection in accordance with IBC, Chapter 17. Structural steel includes all steel elements that resist code-defined loads and whose failure would affect life safety. Items to be inspected include, but are not limited to, mechanical / electrical supports, beams, stringers, columns, access walkways, and stairways.

B. Fabricator Qualifications:
   1. A qualified Fabricator must participate in the AISC 207 Certification program and be designated an AISC Certified Plant, Category BU (Certified Building Fabricator).

PART 2 PRODUCTS

2.01 MATERIALS

A. Steel:
   1. Materials for structural steel shall be as specified in Table A.

Table A - Steel Materials

Material	Specification
M-shapes	ASTM A992
S-shapes	ASTM A992
Channels	ASTM A36
Angles	ASTM A36
Plates	ASTM A36
HP-shapes	ASTM A572 Grade 50
Rolled wide-flange sections (W-shapes) and WTs	ASTM A992
Pipe sections	ASTM A53, Type E or S, Grade B (Fy = 35 ksi)
Round Hollow Structural Sections (HSS)	ASTM A500, Grade C (Fy=46 ksi min)
Square and Rectangular Hollow Structural Sections (HSS)	ASTM A500, Grade C (Fy = 50 ksi min)
Stainless steel bolts (used at stainless steel and aluminum framing unless noted otherwise)	ASTM F593, Type 316
Stainless steel nuts and washers (used at stainless steel and aluminum framing unless noted otherwise)	ASTM F594, Type 316
Steel bolts (used at galvanized and painted steel framing)	Galvanized ASTM F3125 Gr. A325

Table A - Steel Materials

Material	Specification
Carbon steel nuts and washers	Galvanized ASTM A563 nuts and galvanized ASTM F436 washers
Anchor bolts	Refer to Section 05 05 20

B. Stainless Steel:

1. Materials for structural stainless steel shall be as specified in Table B. All stainless steel shall be passivated per ASTM A380.

Table B – Stainless Steel Materials

Material	Specification
Hot-rolled and extruded structural shapes	ASTM A276, Type 316, finish per ASTM A484
Hollow structural sections (HSS)	ASTM A554, Type 316, finish per ASTM A554
Welded round pipe	ASTM A312, Type 316, finish per ASTM A999
Built-up I-shape, channel, angle, tee, & box section shapes (laser & laser hybrid)	ASTM A276, Type 316, finish per ASTM A1069
Bolts	Use stainless steel bolts for stainless steel framing (see Table A above)
Plates	ASTM A480, Type 316, finish per ASTM A480
Anchor bolts	Refer to Section 05 05 20

C. Aluminum:

1. Materials for structural aluminum shall be as specified in Table C.

Table C - Aluminum Materials

Material	Specification
Structural shapes	Alloy 6061-T6 per ASTM B308
Bolts	Use stainless steel bolts for aluminum framing (see Table A above)
Guardrail and handrail pipe	Alloy 6061-T6 or 6063-T6 per ASTM B241
Plates	Alloy 6061-T6 per ASTM B209
Anchor bolts	Refer to Section 05 05 20

PART 3 EXECUTION

3.01 GOVERNING DOCUMENTS

A. The following paragraphs are primarily written to be applicable to structural steel. Where stainless steel or aluminum are utilized the applicable governing document(s) for that material shall be adhered to as necessary.

3.02 EXAMINATION

A. Examine and accept conditions before beginning work.

3.03 FABRICATION

A. Fabrication of steel shall be in accordance with the applicable provisions of the AISC Steel Construction Manual and AISC 360. Fabrication of stainless steel shall be in accordance with the applicable provisions of AISC 313 and AISC 370. Fabrication of aluminum shall be in accordance with Aluminum Design Manual. Fabrication and assembly shall be done in the shop to the greatest extent possible. The fabricating plant shall be certified under AISC 207 for Category BU.

B. Compression joints depending on contact bearing shall have a surface roughness not more than 500 micro-inches and ends shall be square within the tolerances for milled ends specified in ASTM A6.

C. Shop splices of members will be permitted only where indicated on the Drawings. Splices not indicated require the approval of the Owner's Representative.

D. Verify measurements at the job site prior to fabrication. Fabricate to match job site measurements.

E. Provide bolt holes as indicated for securing other work to structural framing. Conform to AISC 325 and AISC 360 guidelines or contact Owner's Representative for approval for bolt holes not indicated on drawings.

F. Other work shall be routed around structural steel framing members to the extent possible. Where not indicated on the design drawings, additional cuts, alterations, and holes for the passage of other work through steel framing members require the approval of the Owner's Representative and shall be addressed in accordance with AISC 303.

3.04 INSTALLATION

A. General:
   1. Erection of structural steel shall be in accordance with the applicable provisions of AISC Steel Construction Manual (AISC 325). Erection plan shall conform to AISC 303. For low-rise structural steel buildings, 60 feet tall or less and a maximum of 2 stories, the structure shall be erected in accordance with AISC Design Guide 10.
   2. Coordinate installation of anchor bolts and other connectors required for securing structural steel in place. Refer to Section 05 05 20 for additional information regarding anchor bolts.
   3. Employ a registered professional engineer or surveyor for accurate erection of the structural framing. Check elevations of concrete and locations of anchor bolts before erection proceeds and report discrepancies to the Owner's Representative.
   4. Placement tolerances shall be in accordance with AISC 303 and AISC 360
   5. After final positioning of members, provide full bearing under base plates and bearing plates using non-shrink grout. Place non-shrink grout in accordance with the Manufacturer's instructions. Grout shall be cured prior to loading of the structure.
   6. Protect dissimilar metals from galvanic corrosion by means of pressure tapes, coatings, or isolators. Protect aluminum in contact with concrete or grout with a heavy coat of bituminous paint.

7. Metalwork to be embedded in concrete shall be placed accurately and held in correct position while the concrete is placed. The surfaces of metalwork in contact with or embedded in concrete shall be thoroughly cleaned without damaging any metalwork coatings (if applied).
8. Structural steel completely encased in concrete shall not be galvanized or painted and shall have a clean surface for bonding to concrete.
9. Metalwork which is bent, broken or otherwise damaged shall be repaired or replaced at the Contractor's expense.

B. Welding:
1. Welding shall be done by welders, welding operators, and tackers who have been qualified by tests as prescribed by AWS to perform the type of work required. The quality of welding shall conform to AWS Codes.
2. Develop and submit the Welding Procedure Specifications (WPS) for all welding, including welding done using prequalified procedures.
3. Provide continuous seal welds for plates or structural shapes that are exposed to or submerged in water or wastewater.

C. Bolted Connections:
1. Bolted connections, unless noted otherwise, shall conform to AISC 360 and the RSCS and shall be bearing type connections with bolts snug-tight. Punch, subpunch and ream, or drill bolt holes perpendicular to the surface of the member. Finished holes shall be 1/16 inch larger than the nominal size of the bolts for bolts less than one inch diameter, unless otherwise specified. Finished holes shall be 1/8 inch larger than the nominal size of the bolts for bolts one inch diameter and larger, unless otherwise specified. Bolts, nuts, and washers shall be clean of dirt and rust and lubricated immediately prior to installation. No drifting of bolts or enlargement of holes will be allowed to correct misalignment. Holes shall not be cut or enlarged by burning. Mismatched holes shall be corrected with new material. Bolts may not be re-used. Specifics to bolted connection types are as follows:
a. Snug-tight: Typical bearing type connections per the requirements of the RCSC specification. Note that thru-bolted HSS connections are only allowed to be snug-tight.

3.05 CORROSION PROTECTION

A. Unless otherwise specified, carbon structural steel shall be galvanized. If coatings are indicated on the Drawings or elsewhere in the Specifications, coat in accordance with Section 09 90 00. Coating surface preparation shall be as specified in Section 09 90 00 and shall include the following operations:
1. Grind the exterior and interior edges of all flame-cut plates or members to a smooth surface.
2. Grind all sharp edges from sheared plates and punched holes.
3. Grind uneven or rough welds with high beads to a smooth finish.

3.06 CLEANING

A. After installation, damaged surfaces of shop primed metals shall be cleaned and touched up with the same material used for the shop coat. Damaged surfaces of galvanized metals shall be repaired as specified in Section 05 05 14.

END OF SECTION

SECTION 05 50 00

METAL FABRICATIONS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Custom fabricated metal items and certain manufactured units not otherwise indicated to be provided under work of other specification sections.
   2. Seat angle frames
   3. Fall arrest anchors
   4. Iron castings
   5. Ship's ladders
   6. U-channel concrete inserts
   7. Cover plates and frames
   8. Pipe sleeves
   9. Bollards
   10. Stairs
   11. Safety nosings at concrete stairs
   12. Miscellaneous metal fabrications not covered elsewhere

1.02 RELATED SECTIONS

A. This section contains specific references to the following related sections. Additional related sections may apply that are not specifically listed below.
   1. Section 01 73 24 Design Requirements for Nonstructural Components and Nonbuilding Structures
   2. Section 05 05 14 Hot-Dip Zinc Coating
   3. Section 05 05 20 Anchor Bolts
   4. Section 05 10 00 Structural Metal Framing
   5. Section 05 52 10 Aluminum Railings
   6. Section 05 53 10 Metal Gratings and Stair Treads
   7. Section 09 90 00 Painting and Coating

1.03 REFERENCES

A. The references listed below are a part of this section. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.

Reference	Title
Aluminum Design Manual	The Aluminum Association, Aluminum Design Manual with Specifications and Guidelines for Aluminum Structures

Reference	Title
AISC 303	Code of Standard Practice for Steel Buildings and Bridges
AISC 360	Specification for Structural Steel Buildings
AISC Steel Construction Manual	American Institute of Steel Construction, Manual of Steel Construction
ANSI A14.3	Standard for Ladders - Fixed - Safety Requirements
ASTM A36	Carbon Structural Steel
ASTM A48	Gray-Iron Castings
ASTM A53	Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
ASTM A108	Steel Bar, Carbon and Alloy, Cold-Finished
ASTM A123	Zinc (Hot Dip Galvanized) Coatings on Iron and Steel Products
ASTM A153	Zinc Coating (Hot-Dip) on Iron and Steel Hardware
ASTM A193	Alloy-Steel and Stainless Steel Bolting for High Temperature or High Pressure Service and Other Special Purpose Applications
ASTM A194	Carbon and Alloy Steel Nuts for Bolts for High Pressure or High Temperature Service, or Both
ASTM A240	Chromium and Chromium Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications
ASTM A276	Stainless Steel Bars and Shapes
ASTM A283	Low and Intermediate Tensile Strength Carbon Steel Plates
ASTM A307	Carbon Steel Bolts, Studs, and Threaded Rod 60000 psi Tensile Strength
ASTM A312	Seamless, Welded, and Heavily Cold Worked Austenitic Stainless Steel Pipes
ASTM A320	Alloy-Steel Bolting Materials for Low Temperature Service
ASTM A325	Structural Bolts, Steel, Heat Treated 120/105 ksi Minimum Tensile Strength
ASTM A380	Standard Practice for Cleaning, Descaling, and Passivation of Stainless Steel Parts, Equipment, and Systems
ASTM A384	Standard Practice for Safeguarding Against Warpage and Distortion During Hot-Dip Galvanizing of Steel Assemblies
ASTM A489	Carbon Steel Lifting Eyes
ASTM A500	Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes
ASTM A554	Welded Stainless Steel Mechanical Tubing
ASTM A563	Carbon and Alloy Steel Nuts
ASTM A572	High-Strength Low-Alloy Columbium-Vanadium Structural Steel
ASTM A653	Steel Sheet, Zinc Coated (Galvanized) or Zinc Iron Alloy Coated (Galvannealed) by the Hot Dip Process
ASTM A780	Repair of Damaged and Uncoated Areas of Hot Dip Galvanized Coatings
ASTM A786	Hot-Rolled Carbon, Low-Alloy, High-Strength Low-Alloy, and Alloy Steel Floor Plates
ASTM A793	Rolled Floor Plate, Stainless Steel
ASTM A924	Steel Sheet, Metallic-Coated by Hot-Dip Process
ASTM A992	Structural Steel Shapes
ASTM A1011	Steel, Sheet and Strip, Hot-Rolled, Carbon, Structural, High-Strength Low-Alloy, High-Strength Low-Alloy with Improved Formability, and Ultra-High Strength
ASTM B209	Aluminum and Aluminum-Alloy Sheet and Plate
ASTM B210	Aluminum and Aluminum-Alloy Drawn Seamless Tubes
ASTM B211	Aluminum and Aluminum-Alloy Rolled or Cold Finished Bar, Rod, and Wire
ASTM B221	Aluminum and Aluminum-Alloy Extruded Bars, Rods, Wire, Profiles, and Tubes

Reference	Title
ASTM B241	Aluminum and Aluminum-Alloy Seamless Pipe and Seamless Extruded Tube
ASTM B308	Aluminum-Alloy 6061-T6 Standard Structural Profiles
ASTM B429	Aluminum-Alloy Extruded Structural Pipe and Tube
ASTM B632	Aluminum-Alloy Rolled Tread Plate
ASTM D1056	Flexible Cellular Materials - Sponge or Expanded Rubber
ASTM F436	Hardened Steel Washers
ASTM F468	Nonferrous Bolts, Hex Cap Screws, SocketHead Cap Screws and Studs for General Use
ASTM F593	Stainless Steel Bolts, Hex Cap Screws, and Studs
ASTM F594	Stainless Steel Nuts
AWS D1.1	Structural Welding Code - Steel
AWS D1.2	Structural Welding Code - Aluminum
AWS D1.6	Structural Welding Code - Stainless Steel
OSHA 29 CFR 1910.27	Fixed Ladders
OSHA 29 CFR 1926.502	Fall Protection Systems Criteria and Practices
SSPC SP5	White Metal Blast Cleaning
IBC	International Building Code

1.04 DEFINITIONS

A. Galvanize: Hot-dip galvanize per ASTM A123 or ASTM A153, per Section 05 05 14.

1.05 SUBMITTALS

A. Action Submittals:
   1. Procedures: Section 01 33 00
   2. A copy of this specification section with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements.
   3. Check-marks (✓) shall denote full compliance with a paragraph as a whole. Deviations shall be underlined and denoted by a number in the margin to the right of the identified paragraph. The remaining portions of the paragraph not underlined will signify compliance on the part of the Contractor with the specifications. Include a detailed, written justification for each deviation. Failure to include a copy of the marked-up specification sections, along with justification(s) for any requested deviations to the specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration
   4. Manufacturer's product data.
   5. Detailed Shop Drawings:
      a. Fabrication drawings showing layouts, connections to structural system, and anchoring details.
      b. Erection and installation drawings indicating thickness, type, grade, class of metal, coating system and dimensions.
      c. Construction details, reinforcement, anchorage, and installation with relation to the building construction.
   6. Welding procedures and welder certificates and qualifications.

7. U-Channel Concrete Inserts: Manufacturer's product description and allowable load tables.
8. Passivation method for stainless steel fabrications.
9. Fall Arrest Anchor Certificate:
    a. Certify fall arrest system is designed to meet OSHA 29 CFR 1926.502 specified performance requirements.
    b. Signed and sealed by a Professional Engineer licensed in the state in which the project is located.

1.06 QUALITY ASSURANCE

A. Qualifications
    1. Fabricator shall have a minimum of five years experience in fabrication of metal specified.

B. Certificates
    1. Certified welding procedures and welding operators in accordance with AWS. Welding operator certificates shall be no more than one-year old and the welder shall have used the welding process to be performed within the last six months.

C. The use of salvaged, reprocessed or scrap materials will not be permitted.

D. Shop Assembly: Items in the shop shall be preassembled to the greatest extent possible, so as to minimize field splicing and assembly of units. Units shall be disassembled only to the extent necessary for shipping and handling limitations. Units shall be clearly marked for reassembly and coordinated installation.

1.07 DELIVERY, STORAGE AND HANDLING

A. Avoid damage during delivery and handling of fabrications.

B. Store off the ground on skids or other supports to keep items free of dirt and other foreign debris and to protect against corrosion.

PART 2 PRODUCTS

2.01 MATERIALS

A. Materials for miscellaneous metalwork are specified in the following table.

Material	Specification
Steel	
Sheets, plates and shapes (except W shapes)	ASTM A36
W shapes	ASTM A992
Pipe	ASTM A53, Grade B
Square/rectangular tubing	ASTM A500, Grade B
Headed Anchor Studs	ASTM A108

Material	Specification
Carbon steel bolts	ASTM A307, Grade A
High strength bolts	ASTM A325 (Type 1)
Nuts	ASTM A563
Washers	ASTM F436
Stainless Steel	
Sheet and Plates	ASTM A240, Type 316 or 316L
Shapes, bars, and similar items	ASTM A276, Type 316 or 316L
Pipe	ASTM A312, Type 316 or 316L
Headed Anchor Studs	ASTM A276, Type 316L
Bolts	ASTM F593, Type 316
Nuts	ASTM F594, Type 316
Aluminum	
Sheets and plates	ASTM B209, Type 6061-T6
Bars, flats and similar items	ASTM B211 or B221, Type 6061-T6
Shapes	ASTM B308, Type 6061-T6
Round tubing and pipe	ASTM B241, Type 6061-T6
Square and rectangular tubing	ASTM B221, Type 6063-T52
Pipe	ASTM B211 or B241, Type 6061-T6
Bolts, Stainless Steel	ASTM F593, Type 316
Nuts, Stainless Steel	ASTM F594, Type 316
Checker Plate	
Steel	ASTM A786
Stainless steel	ASTM A793, Type 304
Aluminum	ASTM B632, Type 6061-T6
Other steel items	
Iron castings	ASTM A48
Eyebolts	ASTM A489
Threaded rods	ASTM A36

2.02 FABRICATION

A. General

1. Conform to AISC or Aluminum Association standards as applicable. Where Code defined loads apply, also conform to IBC requirements.
2. Shop and field welding shall conform to the requirements of AISC, the Aluminum Design Manual, and applicable AWS procedures and specifications as required by the material being welded.
3. Grind exposed joints flush and smooth with adjacent finish surface. Make exposed joints butt, tight, flush, and hairline. Remove burrs and weld splatter. Ease exposed edges to small uniform radius.

4. Holes shall be punched 1/16 inch larger than the nominal size of the bolts, unless otherwise specified. Whenever needed, because of the thickness of the metal, holes shall be subpunched and reamed or shall be drilled.
5. Fabrication, including cutting, drilling, punching, threading and tapping required for fabrications or adjacent work, shall be performed prior to galvanizing.

B. Seat Angle Frames
1. Provide recessed seat angle frames for grating and floor plates. Miter corners to ensure accurate fit. Match depth of recess with grating or floor plate thickness. Anchor frames in concrete with headed studs. Steel angle support frames shall be stainless steel, ASTM A276, Type 316, unless indicated otherwise.

C. Fall Arrest Anchors
1. Fall arrest anchors shall meet requirements of OSHA 29 CFR 1926.502. Anchorages attached to personal fall arrest equipment shall be capable of supporting at least 5,000 pounds per employee attached, or shall be designed, installed, and used as part of a complete personal fall arrest system which maintains a safety factor of at least two. Type of anchor shall fit the application and substrate material.
2. Fall arrest anchors shall be manufactured by:
   a. Thaler Metal Industries
   b. DBI-SALA
   c. Approved Equal

D. Iron Castings
1. Castings shall be as specified on the Drawings. Castings weighing less than 100 pounds shall be galvanized after machining. Castings weighing greater than 100 pounds shall be galvanized where specified.

E. Ladders
1. Aluminum Ladders: Ladders shall be vendor supplied pre-engineered aluminum ladders. Ladders shall be fabricated of alloy 6063-T6. Rungs shall have non-slip grip surface. Finish shall be anodized. Fabricate ladders with rails, rungs, landings and cages to meet applicable requirements of OSHA 29 CFR 1910.27. Rungs shall be a minimum clear length of 16 inches, uniformly spaced at a maximum of 12 inches and plug welded into side rails. Install ladders so that the distance from the centerline of rungs to the finished wall surface is not less than 7 inches nor more than 12 inches. Provide clip angle supports bolted to the side rail at the top. Provide intermediate clip angle lateral supports at a maximum of 10 feet on center.
2. Ladder Safety Post:
   a. Provide a telescoping ladder safety post at ladders below all floor and roof hatches, and other coverings.
   b. The ladder safety post shall be pre-assembled from the manufacturer.
   c. Performance characteristics:
      1) Post shall lock automatically when fully extended.
      2) Post shall have controlled upward and downward movement.
      3) Release lever shall disengage the post to allow it to be returned to its lowered position.

4) Post shall have adjustable mounting brackets to fit ladder rung spacing up to 14” on center and clamp brackets to accommodate ladder rungs up to 1-3/4” in diameter.
5) Post: Manufactured of high strength square tubing with a pull up loop provided at the upper end of the post to facilitate raising the post.
6) Material of construction: Aluminum
7) Balancing spring: Stainless steel spring balancing mechanism to provide smooth, easy, controlled operation when raising and lowering the safety post.

d. Acceptable products include:
1) LadderUp Safety Post by Bilco
2) Ladder Safety Post Model SP by Nystrom Inc.
3) Approved equal

F. Ship Ladders
1. Provide Ship Ladders in accordance with IBC 1009.11. Fabricate stringers and framing of steel plates or shapes. Bolt or weld connections and anchors to supporting construction. Provide treads with non-slip surface as specified for safety treads. Provide railings as specified.

G. Cover Plates and Frames

Fabricate aluminum cover plates weighing not more than 80 pounds per cover with a raised pattern nonslip top surface conforming to ASTM B632. Reinforce to sustain a live load of 100 pounds per square foot (foot traffic only) or as indicated on the Drawings. Frames shall be stainless steel angles and plates, with stainless steel

headed anchors welded to frame for anchoring to concrete. Miter and weld corners and butt joint straight runs. Provide flush drop handles for removal. Remove sharp edges and burrs from cover plates and exposed edges of frames. Weld connections and grind top surface smooth. Provide 1/8 inch clearance at edges.

H. Pipe Sleeves
1. Unless otherwise indicated on the Drawings, fabricate pipe sleeves from schedule 40 steel pipe with 3/16 inch thick by 3 feet wide seep ring continuously seal welded to the outside of the pipe. Galvanize after fabrication in accordance with ASTM A123.

I. Bollards
1. Provide minimum 6 inch galvanized standard weight steel pipe or as indicated on the Drawings. Pipe to be in accordance with ASTM A53. Anchor posts in concrete and fill solidly with concrete of a minimum compressive strength of 2500 psi. Coat galvanized pipe above grade in accordance with Section 09 90 00. Top coat cover color shall be safety yellow. Install reflective tape near top of bollards similar to WA DOT Bollard Type 2.

J. Stairs – Aluminum
1. Provide aluminum stairs complete with stringers, grating treads, landings, columns, guardrails, handrails, and necessary bolts and other fastenings.
2. Fabricate stringers of structural aluminum channels. Provide closures for exposed ends of stringers. Construct landings of structural channel headers and miscellaneous framing members.

3. Grating Treads and Landings: Provide aluminum grating for treads and landings conforming to Section 05 53 10. Fabricate grating treads with abrasive nosing and with angle or plate carrier at each end for stringer connections. Secure treads to stringers with bolts. Fabricate grating landings with nosing that matches grating treads. Provide toe-plates at open-sided edges of landing.
4. Provide railings for stairs and platforms in accordance with Section 05 52 10.

K. Safety Nosings at Concrete Stairs
1. Safety stair treads shall be 4 inches wide and manufactured by:
   a. Safe T Metal Company Incorporated, Style AX;
   b. Wooster Products Incorporated, Alumogrit, Type 101;
   c. Approved Equal.

L. Other Miscellaneous Steel Metalwork
1. Other miscellaneous steel metalwork including embedded and non-embedded steel metalwork, hangers and inserts shall be as specified or shown on the Drawings, and shall be galvanized after fabrication unless otherwise noted.

2.03 FINISHES

A. Galvanizing
1. Galvanize items specified to be zinc-coated, after fabrication where practicable. Galvanizing in accordance with ASTM A123, ASTM A153, ASTM A653 or ASTM A924, Z275 G90, as applicable. Galvanize anchor bolts, grating fasteners, washers, and parts or devices necessary for proper installation, unless indicated otherwise.
2. Repair damaged Zinc-Coated surfaces with galvanizing repair method and paint conforming to ASTM A780 or by application of stick or thick paste material specifically designed for repair of galvanizing, as approved by Owner's Representative.
3. Safeguard against warpage and distortion during galvanizing of steel in accordance with ASTM A384. Straighten items after galvanizing so that they are straight, free of racking and distortion.

B. Shop Painting
1. Prepare and coat surfaces in accordance with Section 09 90 00.
2. Steel to be embedded in concrete shall be free of dirt and grease.

C. Aluminum Surfaces
1. Surface condition aluminum before finishes are applied. Remove roll marks, scratches, rolled-in scratches, kinks, stains, pits, orange peel, die marks, structural streaks, and other defects which will affect uniform appearance of finished surfaces.
2. Aluminum finishes for unexposed sheet, plate and extrusions may have mill finish as fabricated.
3. Provide other aluminum items with a standard mill finish.
4. Provide a coating thickness not less than that specified for protection.
5. Provide decorative type finishes for items used in interior occupied locations or architectural type finish for items used in exterior locations.
6. Provide a polished satin finish on items to be anodized.

D. Stainless Steel Passivation

1. Stainless steel to be cleaned, descaled, and passivated after fabrication in accordance with ASTM A380. Passivate to remove iron compounds from the surface of the stainless steel.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verify measurements at the site. Include field dimensions in shop drawings.

B. Examine and accept existing conditions before beginning work.

3.02 PREPARATION

A. Make provisions for erection loads with temporary bracing. Keep work in alignment.

B. Supply items required to be cast into concrete or embedded in masonry with setting templates.

3.03 INSTALLATION

A. Install items plumb, level and square, accurately fitted, and free from distortion or defects. Install rigid, substantial, and neat in appearance.

B. Allow for erection loads and provide temporary bracing to maintain true alignment until completion of erection and installation of permanent attachments.

C. Fieldwork shall not be permitted on galvanized items. Drilling of bolts or enlargement of holes to correct misalignment will not be allowed.

D. Protect encased or embedded dissimilar metals (both metals must be encased or embedded) from galvanic corrosion by means of pressure tapes, coatings or isolators.

E. Place metalwork to be embedded in concrete accurately and hold in correct position while the concrete is placed or, if indicated, form recesses or blockouts in the concrete. Thoroughly clean the surfaces of metalwork in contact with or embedded in concrete.

F. Seat angles, supports and guides: Set seat angles for grating and supports for floor plates so that they maintain the grating and floor plates flush with the floor.

G. Ladder Safety Post: Comply with manufacturer’s installation instructions.

H. Pipe Sleeves: Provide where pipes pass through concrete or masonry. Holes drilled with a rotary drill may be provided in lieu of sleeves in existing walls. Provide a center flange for water stoppage on sleeves in exterior or water bearing walls. Provide a rubber caulking sealant or a modular mechanical unit to form a watertight seal in the annular space between pipes and sleeves.

I. U-Channel Concrete Inserts: Provide as indicated for pipe supports and where otherwise specified or shown on Drawings.

J. Safety Nosings: Unless otherwise specified, safety stair nosing shall be installed on concrete stairs. Nosing shall be secured to concrete with suitable anchors at 15 inches on center and not more than 4 inches from the ends. 1/8 inch thick rubber tape shall be provided at both ends and cut to fit shape of nosing prior to concrete placement.

K. Concrete: Pan-filled stairs to be constructed in accordance with Section 03 30 00. Finish concrete with a “nonslip” finish with “very flat” tolerance as specified in ACI 301.

L. Fastening to Construction-In-Place: Provide anchorage devices and fasteners where necessary for fastening fabricated items to construction-in-place. Design anchorage devices in accordance with Section 01 73 24. Anchor bolts to be in accordance with Section 05 05 20.

M. Set steel stair baseplates on wedges, or shims. After stairs have been positioned and aligned, tighten anchor bolts. Do not remove wedges or shims, but if protruding, cut off flush with edge of bearing plate before packing with grout.

N. Railing: Adjust railing systems before anchoring to ensure matching alignment at abutting joints. Space posts at spacing required by design loads and as limited on Drawings. Plumb posts in each direction.

3.04 REPAIR/RESTORATION

A. Galvanized
   1. Maximum area to be repaired shall not be more than 1/2 of 1 percent of the surface area or 36 sq. in. per ton of piece weight, whichever is less. Damage in excess of this requirement shall be repaired by stripping and recoating entire piece.
   2. Clean damaged areas to SSPC-SP5. Repair with zinc-rich paint in accordance with the manufacturer's instructions and with ASTM A780, Annex A2. Minimum thickness requirements shall be in accordance with ASTM A123.
   3. Use zinc-rich repair paint. Acceptable manufacturers:
      a. LPS, Cold Galvanize
      b. ZRC Worldwide, ZRC Galvilite
      c. Approved Equal

B. Painted
   1. After installation, clean and touch up damaged areas with the same materials used for the shop coat.

3.05 FIELD QUALITY CONTROL

A. Electrolytic Protection

B. Protect dissimilar metals from galvanic corrosion by means of pressure tapes, coatings, or isolators. Aluminum in contact with concrete or grout shall be protected with a heavy coat of bituminous paint.

C. 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 in accordance with requirements of ASTM A380.
4. Brushes used to remove foreign substances shall utilize only stainless steel or nonmetallic bristles.

END OF SECTION

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SECTION 05 52 10

ALUMINUM RAILINGS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Prefabricated anodized aluminum component type guardrail and handrail systems; herein referred to as railing.

1.02 RELATED SECTIONS

A. This section contains specific references to the following related sections. Additional related sections may apply that are not specifically listed below.
   1. Section 03 30 00 Cast-in-Place Concrete.

1.03 REFERENCES

A. The references listed below are a part of this section. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.

Reference	Title
Aluminum Design Manual	The Aluminum Association, Aluminum Design Manual with Specifications and Guidelines for Aluminum Structures
ASTM B209	Aluminum and Aluminum-Alloy Sheet and Plate
ASTM B210	Aluminum and Aluminum-Alloy Drawn Seamless Tubes
ASTM B221	Aluminum and Aluminum-Alloy Extruded Bars, Rods, Wire, Profiles, and Tubes
ASTM B429	Aluminum-Alloy Extruded Structural Pipe and Tube
ASTM B483	Aluminum and Aluminum-Alloy Drawn Tube and Drawn Pipe for General Purpose Applications
ASTM F593	Stainless Steel Bolts, Hex Cap Screws, and Studs
ASTM F594	Stainless Steel Nuts
AWS D1.2	Structural Welding Code, Aluminum
OSHA	U.S. Dept. of Labor, Occupational Safety and Health Administration
IBC	International Building Code with local amendments

1.04 SUBMITTALS

A. Action Submittals:
   1. Procedures: Section 01 33 00.
   2. A copy of this specification section with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements.

3. Check-marks (✓) shall denote full compliance with a paragraph as a whole. Deviations shall be underlined and denoted by a number in the margin to the right of the identified paragraph. The remaining portions of the paragraph not underlined will signify compliance on the part of the Contractor with the specifications. Include a detailed, written justification for each deviation. Failure to include a copy of the marked-up specification sections, along with justification(s) for any requested deviations to the specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration.
4. Layout, installation, and detail shop drawings for railing.
5. Design calculations stamped and signed by a licensed professional engineer in the State of Washington. Railing and base support connections to be designed by the Contractor incorporating specified criteria and provisions in the current building code with local governing amendments.

B. Informational Submittals:
1. Material certification for compliance with this specification for aluminum and stainless steel materials.

1.05 QUALITY ASSURANCE

A. General:
1. Railing shall conform to the standards of the Occupational Safety and Health Administration (OSHA) and International Building Code.

1.06 DELIVERY, STORAGE AND HANDLING

A. Cushion wrap complete rails, modules and components to prevent scratching and denting during shipment, storage, and installation.

B. Leave wrap intact, insofar as possible, until railing is completely installed.

PART 2 PRODUCTS

2.01 PERFORMANCE/DESIGN CRITERIA

A. Railing assembly and attachments shall resist a minimum uniform load of 50 pounds per linear foot on the top rail and a concentrated load of 200 pounds (not acting concurrently with the uniform load) applied in any direction. Contractor's supplier and engineer are responsible for designing the guardrail/handrail system along with its base support and anchor bolt size and embedment depth into concrete, or connection to metal framing, to resist the above loading condition taking into account anchor edge distances and concrete strengths at the point of attachment. Contractor shall submit calculations signed and sealed by a professional engineer in the State of Washington.

B. Thermal Movements: Provide railing that allow for thermal movements resulting from the project site maximum range in ambient and surface temperatures. Base engineering calculation on surface temperatures of materials due to both solar heat gain and nighttime sky heat loss.

2.02 MANUFACTURERS

A. Julius Blum & Co., Inc.

B. Golden Railing Inc.

C. Moultrie Manufacturing.

D. American Railing Systems, Inc.

E. Approved equal.

2.03 MATERIALS

Component	Material
Aluminum pipe	ASTM B210 Alloy 65060-T832; ASTM B 221 Alloy 6063-T5/T52; ASTM B 429, Alloy 6063-T832; ASTM B483, Alloy T832
Aluminum plate	ASTM B209, Alloy 6061-T6
Stainless steel bolts	ASTM A593, Type 316
Stainless steel nuts and washers	ASTM A594, Type316

2.04 CONFIGURATION/COMPONENTS

A. Guard Top Rails: Minimum 1 1/2 inch nominal diameter pipe, Schedule 40.

B. Intermediate Rails: Minimum 1 1/2 inch nominal diameter pipe, Schedule 40.

C. Handrails: 1 1/2 inch nominal diameter pipe, Schedule 40.

D. Posts: Minimum 1 1/2 inch nominal diameter pipe, Schedule 80.

E. Provide manufacturer’s heavy-duty base fitting with stainless steel set screws.

F. Provide aluminum toe boards at guardrails, except where concrete curbs are indicated. Aluminum toe boards shall be minimum 3/16-inch thick plate, connected to the posts.

G. Bolts, including anchor bolts, shall be Type 316 stainless steel.

H. Fittings:
   1. Fittings shall be cast aluminum elbows, T-shapes, post brackets and escutcheons. Provide adapter and anchor plugs as required for a complete installation.
   2. Floor sleeves for removable railing shall be stainless steel, embedded in concrete.

2.05 ASSEMBLY/FABRICATION

A. Pipe cuts shall be clean, straight, square and accurate for minimum joint gap. Work shall be done in conformance with the guardrail and handrail manufacturer's instructions. Work shall be free from blemishes, defects, and misfits of any type which can affect durability, strength, or appearance.

B. Guardrailing and handrailing shall be connected by screws or bolts or welding. Holes shall be punched 1/16 inch larger than the nominal size of the bolts, unless otherwise specified. Wherever needed because of the thickness of the metal, holes shall be subpunched and reamed or drilled. Components with mismatched holes shall be replaced. No drifting of bolts or enlargement of holes will be allowed to correct misalignment.

C. Supply components required for anchorage of fabrications.

D. Where shop welding is used, grind exposed joints flush and smooth with adjacent finish surface. Make exposed joints tight and flush. Round exposed edges to small, uniform radius. Use filler alloy rods that will not discolor when anodized, such as ER 5154, ER 5254, ER 5183, ER 5356 or ER 5556 filler alloy rods.

2.06 ISOLATION COATING

A. Isolation coating shall be applied to all aluminum surfaces in contact with concrete, masonry, or dissimilar metals. Use a heavy coat of bituminous paint.

2.07 FINISHES

A. anodized in accordance with the Aluminum Association. Anodize exposed prefabricated components, except stainless steel fasteners, after fabrication.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine and accept existing conditions before beginning work.

B. Field verify measurements for railings before fabrication.

3.02 INSTALLATION

A. Install in accordance with manufacturer's written instructions.

B. Protect dissimilar metals from galvanic corrosion by means of pressure tapes, coatings, or isolators. Aluminum in contact with concrete or grout shall be protected with a heavy coat of bituminous paint.

C. Accurately place metal to be embedded in concrete and hold in correct position while the concrete is placed. Where recesses or blockouts are formed in the concrete, grout metalwork in place after concrete has attained its design strength in accordance with Section 03 30 00.

D. Unless otherwise indicated, field welding of railing is not permitted.

3.03 TOLERANCES

A. Maximum variance from plumb: 1/4 inch.

B. Maximum offset from true alignment: 1/4 inch.

END OF SECTION

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SECTION 05 53 10

METAL GRATINGS AND STAIR TREADS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Aluminumbar grating and stair treads.

1.02 RELATED SECTIONS

A. This section contains references to the following related sections. Additional related sections may apply that are not specifically listed below.
   1. Section 03 30 00 Cast-In-Place Concrete.

1.03 REFERENCES

A. The references listed below are a part of this section. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.

Reference	Title
ASTM B221	Aluminum and Aluminum-Alloy Extruded Bars, Rods, Wire, Profiles, and Tubes
ANSI/NAAMM	Metal Bar Grating Design Manual

1.04 SUBMITTALS

A. Action Submittals:
   1. Procedures: Section 01 33 00.
   1. A copy of this specification section with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements.
   2. Check-marks (✓) shall denote full compliance with a paragraph as a whole. Deviations shall be underlined and denoted by a number in the margin to the right of the identified paragraph. The remaining portions of the paragraph not underlined will signify compliance on the part of the Contractor with the specifications. Include a detailed, written justification for each deviation. Failure to include a copy of the marked-up specification sections, along with justification(s) for any requested deviations to the specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration.
   3. Shop drawings showing placing plans for grating.
      a. Provide layout and fabrication details of support frames.
      b. Provide panel layout with individual panel dimensions.
   4. Manufacturer's product data with load tables.

PART 2 PRODUCTS

2.01 MATERIALS

Component	Material
Aluminum grating bearing and cross bars	ASTM B221, alloy 6061

2.02 ASSEMBLY/FABRICATION

A. Welds:
   1. Grind smooth rough welds and sharp metal edges. Make welds exposed to view uniform and neat.

B. Clearance: provide ¼" separation between panels and at bearing ends of panel to support frame.

C. Grating:
   1. General
      a. Provide serrated grating for slip resistance.
      b. Bearing bars and cross bars are continuous.
      c. Openings shall be banded with bars having the same dimensions as the bearing bars. Band perimeter edges with bars flush at the top surface of the grating and 1/4 inch clear of the bottom surface.
      d. Bars terminating against edge bars shall be welded to the edge bars when welded construction is used.
      e. When crimped or swaged construction is used, bars at edges shall protrude a maximum of 1/16 inch and be peened or ground to a smooth surface.
      f. Fabrication methods employing bending or notching of bearing or cross bars is not permitted.
      g. Maximum grating panel weigh shall not exceed 80 pounds.
   2. Aluminum Grating
      a. Fabricate grating with a mill finish. Punch bearing bars to receive cross bars. After insertion in the bearing bars, cross bars are deformed by a hydraulic press or similar means to permanently lock the bars into the bearing bar openings.
   3. Steel Grating
      a. Use only where specified. Hot-dip galvanized finish after fabrication.
   4. Stainless Steel Grating
      a. Use only where specified. Stainless steel grating to be cleaned, descaled, and passivated after fabrication in accordance with ASTM A380.

D. Stair Treads:
   1. Treads shall match the grating material and type furnished for landings. Use serrated surface for slip resistance. Provide abrasive nosings on each tread. Provide carrier angle at each end for attachment to stair stringers. Attach components to support members with Type 316 stainless steel fasteners.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine and accept existing conditions before beginning work.

B. Field measure grating for proper cutouts and sizes prior to fabrication.

3.02 INSTALLATION

A. Drilling of bolts or enlargement of holes to correct misalignment is not permitted.

B. Protect dissimilar metals from galvanic corrosion by means of pressure tapes, coatings, or isolators. Protect aluminum in contact with concrete with a heavy coat of bituminous paint.

C. Use stainless steel metalwork to be embedded in concrete. Clean surfaces in contact with or embedded in concrete and hold in correct position while concrete is placed. Or, provide formed recesses or blockouts in concrete and then, after concrete has attained design strength, grout metalwork in-place using non-shrink grout.

END OF SECTION

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SECTION 07 21 00

BUILDING INSULATION

PART 1 GENERAL

1.01 DESCRIPTION

A. Scope:
   1. Contractor's Spec Term shall provide all labor, materials, tools, equipment, and incidentals as shown, specified, and required to furnish and install building insulation.
   2. Extent of each type of building insulation is shown and indicated in the Contract Documents.

B. Coordination:
   1. Review installation procedures under this and other Sections and coordinate installation of items that must be installed with or before building insulation Work.

1.02 RELATED SECTIONS (NOT USED)

1.03 REFERENCE STANDARDS

A. ASTM C203 - Standard Test Methods for Breaking Load and Flexural Properties of Block-Type Thermal Insulation.

B. ASTM C531 - Standard Test Method for Linear Shrinkage and Coefficient of Thermal Expansion of Chemical-Resistant Mortars, Grouts, Monolithic Surfacings, and Polymer Concretes.

C. ASTM C578 - Standard Specification for Rigid, Cellular Polystyrene Thermal Insulation.

D. ASTM C665 - Standard Specification for Mineral-Fiber Blanket Thermal Insulation for Light Frame Construction and Manufactured Housing.

E. ASTM C764 - Standard Specification for Mineral Fiber Loose-Fill Thermal Insulation.

F. The references listed here are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.

G. The references listed here indicate those documents in effect at the time of Advertisement for Bids, Invitation to Bid, or on the effective date of the Agreement if there were no Bids. Where documents are referenced in applicable local, state, or federal codes, use the version reference by date in the individual code. If referenced documents are not specifically identified in the applicable code(s), reference to those documents shall indicate the latest version of the documents available at the time of Advertisement for Bids. If referenced documents have been discontinued by the issuing organization, reference to those documents shall mean the latest version of replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued. When document dates are given in the following listing that are not specifically referenced in an applicable code, references to those documents shall mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, discontinued or replaced. For questions, refer to Design Professional's Spec Term.

1.04 SUBMITTALS

A. Action Submittals:
   1. Procedures: Section 01 33 00.
   2. A copy of this specification section, with addendum updates included, and all referenced and applicable sections, with addendum updates included, with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements. Check marks (✓) shall denote full compliance with a paragraph as a whole. If deviations from the specifications are indicated, and therefore requested by the Contractor's Spec Term, each deviation shall be underlined and denoted by a number in the margin to the right of the identified paragraph, referenced to a detailed written explanation of the reasons for requesting the deviation. The Design Professional's Spec Term shall be the final authority for determining acceptability of requested deviations. The remaining portions of the paragraph not underlined will signify compliance on the part of the Contractor's Spec Term with the specifications. Failure to include a copy of the marked-up specification sections, along with justification(s) for any requested deviations to the specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration.
   3. Shop Drawings:
      a. Drawings showing extent of the building insulation Work and all details required for the Work, referencing system components provided as Samples.
   4. Product Data:
      a. Material specifications and general recommendations from building insulation manufacturer for each type of building insulation product. Include manufacturer’s data substantiating that materials comply with Contract Documents.

B. Informational Submittals:
   1. Procedures: Section 01 33 00.

2. Manufacturers' certificates of compliance with specified industry standards.
3. Manufacturer's Instructions: Manufacturer's installation instructions. Indicate by copy of transmittal form that installer has received copy of manufacturer's installation instructions.

1.05 QUALITY ASSURANCE

A. Qualifications:
   1. Manufacturers:
      a. Obtain building insulations that comply in all respects with Copenhagen Amendments to the Montreal Protocol.
      b. Manufacturer shall provide complete technical services including preparation and review of Shop Drawings and submittals, installation methods, and proposed detailing for the Work.
   2. Installer: Engage single installer for each type of building insulation. Each installer shall be skilled, trained, and have record of successful experience in applying and installing each product, and possess successful record of performing work in accordance with recommendations and requirements of manufacturer or that can submit written evidence of being acceptable to manufacturer for providing the required Work. Installers shall employ only tradesmen with specific skill and successful experience in each type of Work required. Submit to Design Professional's Spec Term name and qualifications of each installer with the following information for at least three successful, completed projects per installer:
      a. Names and telephone numbers of owner and Architect or Design Professional's Spec Term responsible for each project.
      b. Approximate contract cost of the building insulation system installed.
      c. Quantity (area) of building insulation installed.

B. Regulatory Requirements: Comply with code interpretations by authorities having jurisdiction at the Site.

1.06 DELIVERY, STORAGE AND HANDLING

A. Delivery and Handling of Materials:
   1. Do not deliver insulation materials to the Site before the time of installation.
   2. Deliver materials in sufficient quantities to allow uninterrupted continuity of the Work.
   3. Handle materials carefully to avoid damage and breakage or compressing of boards to less than their specified thickness, or other damage.
   4. Handle materials in manner that prevents inclusion of foreign materials.

B. Storage of Materials:
   1. Store materials in dry, enclosed area, off ground and away form possible contact with water, ice, and snow.
   2. Prevent damage to materials during storage, including minimizing the time materials are stored at the Site before being incorporated into the Work. Store only sufficient quantity of building insulation materials at the Site required for continuous advancement of the Work without causing delay.

1.07 SITE CONDITIONS

A. Environmental Conditions:
   1. Complete the installation and concealment of building insulation materials as rapidly as possible to avoid damage from adjacent construction operations and adverse weather conditions.
   2. Install building insulations when weather and temperature conditions comply with building insulations manufacturers' written recommendations.
   3. Install building insulations when damaging environmental condition are not forecasted for the time when exposed systems materials components would be exposed to potential damage from the elements.
   4. Protect building insulation Work from precipitation, frost, and direct sunlight.
   5. Do not apply pressure-sensitive tape when temperature is below 35 degrees F or above 110 degrees F.
   6. Record decisions, conditions, and agreements to proceed with the Work when weather conditions may be unfavorable. State reasons for proceeding, along with names of persons involved, and changes or revisions (if any), if required, to allow the Work to proceed.

1.08 SCHEDULING

A. Proceed with building insulation Work when preceding Work is ready to receive the Work of this Section.

B. Proceed with building insulation and associated Work after curbs, blocking, substrate board, nailer strips, vents, drains and other projections through the substrates have been installed, and when substrate construction and framing of openings is complete.

C. Proceed with and complete the Work when materials, equip ment and tradesmen required for the installation of building insulation and backfilling operations are at the Site and ready to follow with the Work in manner that does not leave the Work vulnerable to damage or deterioration.

D. Do not advance installation of building insulation beyond that necessary for proper sequencing of the Work. Do not advance the Work when there is no proper and secure protection from damaging weather and construction activities.

PART 2 PRODUCTS

2.01 SYSTEM PERFORMANCE

A. Performance Criteria:
   1. Thermal Conductivity: Thicknesses shown are for thermal conductivity, k-value at 75 degrees F, specified for each material.
   2. Provide adjusted thicknesses based on thicknesses shown or specified for building insulations, as required to comply with required thermal resistances for material having different thermal conductivity.

2.02 MATERIALS

A. Foam Plastic Insulations: Provide the following types:
   1. General: Rigid, closed-cell, thermally stabilized, extruded, hydrochlorofluro-carbon blown, foam board insulation consisting of 100 percent virgin extruded polystyrene modified resin complying with ASTM C578.
   2. Provide blowing agent with lowest available ozone depletion potential, such as HCFC-142b or better. HCFC-141b is not acceptable.
   3. Roof Insulation: Provide the following:
   4. Provide polyisocyanurate insulation or as shown on Drawings and achieve energy code compliance. Provide a minimum of two staggered layers, unless otherwise indicated. Provide tapered insulation where roof structure does not slope. Roof insulation shall be approved by roofing manufacturer in accordance with the requirements of the roofing warranty. Roof insulation shall meet the requirements of roof manufacturer. Insulation shall have a minimum aged R-value of 5 per inch. Secure insulation as required by the roofing manufacturer to resist wind. Install ½" glass faced gypsum board where insulation is installed over metal deck.

B. Mineral Fiber Insulation: Provide the following types:
   1. General: Provide insulations formed from inorganic mineral fiber extrusions spun at 2,500 degrees F complying with ASTM C665 and ASTM C764.
   2. Loose Mineral Fiber Insulation: Provide non-asbestos rock, slag, or glass processed into fiber and formed into loose resilient wool mass or granular modules complying withASTM C764, Type 1 (for blowing) Type 2 (for pouring).
      a. Physical Properties:
         1) Thermal Conductivity (k), ASTM C764: 0.46 Btu/inch/hour/square foot/degree F.
         2) Ignition Loss: Less than one percent (99 percent pure mineral fiber).
         3) Density, ASTM C764: 1.5 pounds per cubic foot (pcf).
      b. Products and Manufacturers: Provide one of the following:
         1) Industrial Mineral Wool Fiber by Rock Wool Industries, Inc.
         2) FBX Insulating Wool by Fibrex, Inc.
         3) or approved equal.

C. Closed Cell Spray Foam Insulation
   1. Utilize foam insulation at difficult conditions for continuity of tight sealing of air membrane.

PART 3 EXECUTION

3.01 INSPECTION

A. Contractor's Spec Term and installer shall examine substrate and conditions under which building insulation Work will be performed and notify Design Professional's Spec Term in writing of unsatisfactory conditions. Do not proceed with the Work until unsatisfactory conditions have been corrected.

3.02 PREPARATION

A. Surfaces to receive building insulation shall be clean of all debris, dirt, and other contamination before installation begins.

3.03 INSTALLATION

A. General:
   1. Comply with manufacturer's instructions for particular conditions of installation in each case. If printed instructions are not available or do not apply to Site conditions, before proceeding with the Work obtain from manufacturer and submit to Design Professional's Spec Term specific installation recommendations from manufacturer.
   2. Extend insulations full thickness over entire surface to be insulated. Cut and fit tightly around obstructions. Fill voids with insulation.
   3. Apply number of layers of insulation specified, each of required thickness, or required thickness to provide thermal value shown or indicated in the Contract Documents, to make up the total thickness.

B. Correcting Defective Work:
   1. System components that are dislodged, damaged, expanded, broken, penetrated, or crushed by subsequent installation operations or damaged by detrimental weather shall be immediately replaced with undamaged material in compliance with the Contract Documents and properly protected as specified.
   2. Only original installer shall repair or replace deteriorated or defective Work.

3.04 PROTECTION

A. Protection from Elements:
   1. Protect all components of the Work from detrimental weather conditions. Do not allow building insulation materials to become wet or soiled, or covered with ice or snow. Provide continuous protection of materials against damage, wetting and moisture absorption and storing materials as specified
   2. Work that cannot, for reasons acceptable to Design Professional's Spec Term, be covered with complete construction system before onset of weather detrimental to the Work, shall be completely covered and protected in manner that deflects precipitation from building insulations without damaging adjacent Work.
   3. Protect foam plastic building insulation from exposure to sunlight.

B. Protection During Construction:
   1. Protect all components of the Work from construction operations including, but not limited to, backfilling and concrete unit masonry Work, until work is completed and acceptable to Design Professional's Spec Term.
   2. Protect building insulations from damage and abuse by other contractors and installers until readiness for final payment.

3. Do not allow building insulations to come into contact with welding operations or other fire or ignition sources.
4. Do not allow construction traffic not associated with installation of building insulation in the area of building insulation Work. Protect the area from access by other installers and contractors until the building insulation Work has been incorporated into finished construction systems.

C. Building insulation that becomes wet, damaged, or deteriorated shall be promptly removed from the Site and replaced with materials conforming to this Section.

END OF SECTION

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SECTION 07 26 00

VAPOR RETARDERS

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Reinforced vapor retarders.

B. Tape to seal joints and repair vapor retarder.

C. Pipe boots for sealing penetrations.

1.02 RELATED SECTIONS

A. Section 03 30 00 - Cast-in-Place Concrete

B. Section 06 10 00 - Rough Carpentry

1.03 REFERENCE STANDARDS

A. ASTM D882 - Standard Test Method for Tensile Properties of Thin Plastic Sheeting.

B. ASTM D1709 - Standard Test Methods for Impact Resistance of Plastic Film by the Free-Falling Dart Method.

C. ASTM D2582 - Standard Test Method for Puncture-Propagation Tear Resistance of Plastic Film and Thin Sheeting.

D. ASTM D3776/D3776M - Standard Test Methods for Mass Per Unit Area (Weight) of Fabric.

E. ASTM D4833/D4833M - Standard Test Method for Index Puncture Resistance of Geomembranes and Related Products.

F. ASTM E84 - Standard Test Method for Surface Burning Characteristics of Building Materials.

G. ASTM E96/E96M - Standard Test Methods for Gravimetric Determination of Water Vapor Transmission Rate of Materials.

H. ASTM E1643 - Standard Practice for Selection, Design, Installation and Inspection of Water Vapor Retarders Used in Contact with Earth or Granular Fill Under Concrete Slabs.

I. ASTM E1745 - Standard Specification for Plastic Water Vapor Retarders Used in Contact with Soil or Granular Fill under Concrete Slabs.

J. NFPA 701 - Standard Methods of Fire Tests for Flame Propagation of Textiles and Films.

1.04 SUBMITTALS

A. Submit under provisions of Section 013300.

B. Product Data: Manufacturer's data sheets on each product to be used, including:
   1. Preparation instructions and recommendations.
   2. Storage and handling requirements and recommendations.
   3. Installation methods.

C. Samples: Submit manufacturer's samples of reinforced vapor retarders.

D. Verification Samples: For each product specified, two samples, minimum size 5 inches (125 mm) square, representing actual product.

1.05 PRE-INSTALLATION MEETING:

A. Pre-Installation Meeting: Convene a preinstallation meeting two weeks before start of installation of reinforced vapor retarders. Require attendance of parties directly affecting work of this section, including Contractor, Architect, and installer. Review installation, protection, and coordination with other work.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Delivery: Deliver materials to site in manufacturer's original, unopened containers and packaging, with labels clearly identifying product name and manufacturer.

B. Storage:
   1. Store products in manufacturer's unopened packaging until ready for installation.
   2. Store materials in a clean, dry area in accordance with manufacturer's instructions.

C. Handling: Protect materials during handling and installation to prevent damage.

PART 2 PRODUCTS

2.01 MANUFACTURER

A. Acceptable Manufacturers:
   1. Griffolyn, Division of Reef Industries, Inc.
   2. Stego Industries, LLC
   3. W.R. Meadows Inc.
   4. Or approved equal

2.02 REINFORCED VAPOR RETARDERS

A. Reinforced Vapor Retarder: Complying with ASTM E1745 Class B.
   1. Material: 5-ply laminate, combining three layers of high-density polyethylene and two high-strength non-woven cord grids.
   2. Weight: 70 lb/1,000 sq ft (34.2 kg/100 sq m), when tested in accordance with ASTM D3776/D3776M.

3. Puncture Propagation Tear: 55 lb (245 N), when tested in accordance with ASTM D2582.
4. Permeance (Perm): 0.027 grains/hr-sq ft-in Hg (1.551 ng/(Pa-s-sq m)), when tested in accordance with ASTM E96/E96M.
5. Drop Dart: 1,900 g, when tested in accordance with ASTM D1709.
6. Tensile Strength: 225 lb/3,846 psi (1000 N/26.6 MPa), when tested in accordance ASTM D882, 3 inch (76 mm) wide specimen.
7. Puncture Strength: 50 lb (222 N), when tested in accordance with ASTM D4833/D4833M .
8. Usable Temperature Range: Minus 40 to 170 degrees F (minus 40 to 77 degrees C).
9. Application(s):
    a. Use on roof decks under insulation.

2.03 ACCESSORIES

A. General: Ensure accessories are from same manufacturer as reinforced vapor retarders.

B. Mastic Tape: Fab Tape
1. Description: Black, double-sided, asphaltic, pressure-sensitive, mastic tape.
2. Weight: 3.75 pounds per 100 feet (1.7 kg per 30 m).
3. Thickness: 35 mils (0.9 mm).
4. 3 Inch Seam Shear: 35 pounds (156N).

C. Self-Adhesive Repair Tape: Sealant Tape
1. Description: Reinforced white backing with Gray Adhesive.
2. Weight: 3.0 lbs for 4 inch x 50 foot roll.
3. Thickness: 26 mils (0.65 mm).
4. 3 inch Seam Shear: 30 lbs (134 N)

D. Pipe Boots: Pipe boots, factory-fabricated.

E. Batten Strips: Manufacturer's standard for required application.

F. Fasteners: Manufacturer's standard for required application.

PART 3 PART 3 EXECUTION

3.01 EXAMINATION

A. Examine surfaces and areas to receive reinforced vapor retarders. Notify Architect in writing of defects of work and other unsatisfactory site conditions that would cause defective installation of vapor retarders. Do not begin installation until unacceptable conditions have been corrected.

B. Verify site dimensions.

C. Commencement of work will imply acceptance of substrate.

3.02 INSTALLATION

A. Install reinforced vapor retarders in accordance with manufacturer's instructions.

B. Install reinforced vapor retarders in accordance with manufacturer's instructions and ASTM E1643 at concrete slabs.

C. Install vapor retarders continuously at locations as indicated on the drawings. Ensure there are no discontinuities in vapor retarder at seams and penetrations.

D. Install vapor retarders in largest practical widths.

E. Ensure surface beneath vapor retarder is smooth with no sharp projections.

F. Join sections of vapor retarder and seal penetrations in vapor retarder with mastic tape. Ensure vapor retarder surfaces to receive mastic tape are clean and dry.

G. Immediately repair holes in vapor retarder with self-adhesive repair tape.

H. Seal around pipes and other penetrations in vapor retarder with pipe boots in accordance with manufacturer's instructions.

3.03 PROTECTION

A. Protect reinforced vapor retarders from damage until covered by roof insulation.

B. Protect reinforced vapor retarders from damage until covered by wall finish.

C. Protect reinforced vapor retarders from damage during installation of reinforcing steel and utilities and during placement of granular materials or concrete slab.

D. Immediately repair damaged vapor retarder in accordance with manufacturer's instructions.

END OF SECTION

SECTION 07 53 23

ETHYLENE-PROPYLENE-DIENE-MONOMER ROOFING

PART 1 GENERAL

1.01 SUMMARY

A. Scope

1. This Section specifies Ethylene-Propylene-Diene-Monomer Roofing (EPDM) with associated sheet flashing.

B. Pre-roofing Conference

1. Prior to the installation of the EPDM roofing and associated work, Contractor's Spec Term shall schedule and meet at the Site with the roofing installer, the installer of each component of associated work, the installers of deck and insulation to receive roofing work, the installers of other work in and around roofing which must follow the roofing work, including mechanical work, Design Professional's Spec Term and other representatives directly concerned with performance of the Work. Review foreseeable methods and procedures related to the EPDM roofing work, including but not necessarily limited to, the following:
   a. Review project requirements, including Contract Documents.
   b. Review required submittals, both completed and yet to be completed.
   c. Review status of substrate including drying, structural loading limitations and similar considerations.
   d. Review availability of materials, tradesmen, equipment, and facilities required to make progress and avoid delays.
   e. Review required inspection, testing, certifying, and accounting procedures.
   f. Review weather and forecasted weather conditions, and procedures for coping with unfavorable conditions.
   g. Review regulations concerning code compliance, FM compliance, environmental protection, health, safety, fire, and similar considerations.
   h. Review procedures required for protection of roofing during the remainder of the Work.

1.02 REFERENCE STANDARDS

A. 40 CFR 59, Subpart D - National Volatile Organic Compound Emission Standards for Architectural Coatings; U.S. Environmental Protection Agency.

B. ASTM C208 - Standard Specification for Cellulosic Fiber Insulating Board.

C. ASTM C728 - Standard Specification for Perlite Thermal Insulation Board.

D. ASTM C1177/C1177M - Standard Specification for Glass Mat Gypsum Substrate for Use as Sheathing.

E. ASTM C1278/C1278M - Standard Specification for Fiber-Reinforced Gypsum Panel.

F. ASTM C1396/C1396M - Standard Specification for Gypsum Board.

G. ASTM D4263 - Standard Practice for Indicating Moisture in Concrete by the Plastic Sheet Method.

H. ASTM D4637/D4637M - Standard Specification for EPDM Sheet Used in Single-Ply Roof Membrane.

I. ASTM E329 - Standard Specification for Agencies Engaged in Construction Inspection, Testing, or Special Inspection.

J. ASTM E1980 - Standard Practice for Calculating Solar Reflectance Index of Horizontal and Low-Sloped Opaque Surfaces.

K. FM 4470 - Examination Standard for Single-Ply, Polymer-Modified Bitumen Sheet, Built-Up Roof (BUR) and Liquid Applied Roof Assemblies for Use in Class 1 and Noncombustible Roof Deck Construction.

L. FM DS 1-28 - Wind Design.

M. FM DS 1-29 - Roof Deck Securement and Above-Deck Roof Components.

N. FM DS 1-49 - Perimeter Flashing.

O. UL (DIR) - Online Certifications Directory.

P. UL 790 - Standard for Standard Test Methods for Fire Tests of Roof Coverings.

Q. FM Global Research Technical Reports

R. This Section contains references to the above documents. They are a part of this Section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this Section as if referenced directly. In the event of conflict between the requirements of this Section and those of the listed documents, the requirements of this Section shall prevail.

S. Unless otherwise specified, references to documents shall mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid (or on the effective date of the Agreement if there was no Bids). If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued. Where document dates are given in the following listing, references to those documents shall mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, discontinued or replaced. In all cases, the effective version of the State Building Code at the time of Advertisement for Bids or Invitation to Bid shall be considered the building code in effect.

1.03 QUALITY ASSURANCE

A. Warranty

1. Provide a roofing guarantee in the form and content specified, covering the EPDM roofing and associated work specified therein, signed by Contractor's Spec Term and their installer, in accordance with the General Conditions. Provide a two (2)-year roofing guarantee period, starting from the date of the Final Completion certificate issued for the Work, stating that for the duration of the guarantee, Contractor's Spec Term and installer shall be responsible to fix leaks, replace EPDM roofing and roof insulation components damaged by moisture penetration, and other defects caused by improper workmanship or the improper arrangement of the various system components.
2. Special Warranty: A Manufacturer’s standard warranty shall be provided for the elastomeric sheet roofing system in accordance with the General Conditions. The warranty shall be issued directly to the Owner's Spec Term. In no event shall the warranty period be less than twenty (20) years from the date of acceptance of the Work.

B. Qualification of Installer

1. Engage a single installer skilled, trained and with successful experience in the installation of the type of EPDM system specified, who is a recognized roofing installer with specific skill and successful experience in the type of roofing specified in this Section, and equipped to perform workmanship in accordance with the Contract Documents, manufacturer's written instructions for guaranteed construction and the approved Shop Drawings and who agrees to employ only tradesmen with specific skill and successful experience in this type of work. Submit names and qualifications to the Design Professional's Spec Term along with the following information on a minimum of three successful projects:
    a. Names and telephone numbers of Owner's Spec Term, architects, or Design Professional's Spec Terms responsible for projects.
    b. Approximate contract cost of the EPDM roofing.
    c. Amount of area installed.
2. The roofing installer shall be an approved roofing applicator who has qualified for appointment and has been trained by the Manufacturer.
3. Submit proof of acceptability of installer by the Manufacturer to Design Professional's Spec Term.

1.04 ENVIRONMENTAL CONDITIONS

A. Product in this Section shall be subjected to environmental conditions in accordance with Section 011180.

1.05 SUBMITTALS

A. Preconstruction/Action Submittals: The following minimum submittals shall be submitted prior to construction of this element of the Work in accordance with Section 013300.

1. A copy of this 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 or those parts which are to be provided by the Contractor or others shall be provided. Check marks (☐) shall denote full compliance with a paragraph as a whole.
    a. If deviations from the Specifications are indicated, and therefore requested, each deviation shall be underlined and denoted by a number in the margin to the right of the identified paragraph, referenced to a detailed written explanation of the reasons for requesting the deviation. The Design Professional's Spec Term shall be the final authority for determining acceptability of requested deviations.
    b. The remaining portions of the paragraph not underlined shall signify compliance with the Specifications. Failure to include a copy of the marked-up specification sections, along with justification(s) for any requested deviations to the requirements of the Specification shall be cause for rejection of the entire submittal and no further submittal material will be reviewed.
2. Shop Drawings: Submit the following:
    a. Copies of drawings completely dimensioned using field-verified dimensions on plans of each roof area and the accurate location of all roof penetrations roof mounted equipment, curbs, skylights and other features present on the roof areas specified by Design Professional's Spec Term to be included under the Work of this Section and all details of construction and erection, including all flashing details coordinated with Section 07 62 00 - Sheet Metal Flashing and Trim, Section 07 22 16 - Roof Board Insulation, and FM Publications specified, and the location of all walkway pad patterns required by the Manufacturer for warranted construction and as shown. Contractor's Spec Term shall submit all details requiring consideration and the performance of the details shall be approved by the EPDM roofing manufacturer for guaranteed construction as specified.
3. Product Data
    a. Manufacturer's specifications and product manuals indicating product information correlated to specified requirements, Manufacturer's installation instructions, maintenance instructions and other data as may be required by Design Professional's Spec Term
    b. Copies of the FM Global Loss Prevention Data Sheets and appropriate FM Global Research Technical Reports, indicating compliance with wind uplift pressure-resistant performance criteria, and the requirements for FM Approved 1-90 system construction and perimeter securement conditions.
    c. Warranty specified in this Section.

4. Certificates
    a. Contractor's Spec Term's Review: Accompanying approval request, submit to Design Professional's Spec Terma written statement signed by Contractor's Spec Term, stating that the Contract Documentsfor roofing, insulation, and flashing have been reviewed with an agent of the roofing material manufacturer and that they are in agreement that the selected systems are proper, compatible and that the details shown are not in conflict with the roofing manufacturer's roofing, insulation, and flashing details. Show by copy of transmittal form that a copy of the statement has been transmitted to the Manufacturer.
    b. Statement of Application: Upon completion of the Work, submit a statement to Design Professional's Spec Term signed by Contractor's Spec Term stating that the Work complies with the requirements of these Specifications and the installation methods comply with the Manufacturer's printed instructions and were proper and adequate for the condition of installation and use.
5. Samples
    a. 12-inch by 12-inch sheet of each item specified and 6-inch-long pieces of each required system component to be used in the Work.
    b. Each fastener type required marked as to type of material and with their intended purpose in the Work.
    c. All components of the EPDM roofing and flashing labeled with their intended use in the Work. Compliance with all other requirements is exclusive responsibility of Contractor's Spec Term.
6. Evidence of applicator qualifications as specified this Section, Qualification of Applicator.
7. Operations and Maintenance Data: For membrane roofing system to include in maintenance manuals.
8. Warranty documentation as specified in this Section.

PART 2 PRODUCTS

2.01 ACCEPTABLE PRODUCTS

A. Manufacturers
    1. The Design Professional's Spec Term believes that the Manufacturers indicated in this Section are capable of producing equipment and products, which will satisfy the requirements of this Section. This statement, however, shall not be construed as an endorsement of a particular Manufacturer or product, nor shall it be construed that a named Manufacturer's standard product will comply with the requirements of this Section.
    2. Candidate Manufacturers:
        a. Carlisle Syn Technical Systems Corporation,
        b. Firestone Building Products Company,
        c. Or Approved Equal.

B. Manufacturer Qualifications
    1. The Manufacturer shall have ten (10) years of experience manufacturing EPDM roofing in similar-sized projects.

2.02 MATERIALS

A. Materials specified are considered the minimum acceptable for the purposes of durability, strength, and resistance to erosion and corrosion. The Contractor's Spec Term may propose alternative materials for the purpose of providing greater strength or to meet required stress limitations. However, alternative materials must provide at least the same qualities as those specified for the purpose. If alternatives are proposed, the proposals shall be accompanied with documentation supporting the claimed superiority of the proposed substitutions. The Design Professional's Spec Term shall be the sole decider in the equivalency of alternative materials of construction.
   1. EPDM: ASTM D4637/D4637M, uniform, flexible, white, EPDM sheet.
      a. Type I, non-reinforced.
      b. Thickness: 60 mils, nominal.
   2. Acceptable Products and Manufacturers: Provide one of the following:
      a. Sure-White Fully Adhered Roofing System and 20 Year Total System Warranty by Carlisle SynTec Systems Division of Carlisle Corporation.,
      b. RubberGard EcoWhite Fully Adhered Roofing System and 20 Year Total System Warranty by Firestone Building Products., or
      c. or approved equal.

B. General: Auxiliary membrane roofing materials recommended by roofing system manufacturer for intended use and compatible with membrane roofing.
   1. Liquid-type auxiliary materials shall comply with VOC limits of authorities having jurisdiction.
   2. Adhesives and sealants that are not on the exterior side of weather barrier shall comply with the following limits for VOC content when calculated according to 40 CFR 59, Subpart D (EPA Method 24):
      a. Plastic Foam Adhesives: 50 g/L.
      b. Gypsum Board and Panel Adhesives: 50 g/L.
      c. Multipurpose Construction Adhesives: 70 g/L.
      d. Fiberglass Adhesives: 80 g/L.
      e. Single-Ply Roof Membrane Adhesives: 250 g/L.
      f. Single-Ply Roof Membrane Sealants: 450 g/L.
      g. Nonmembrane Roof Sealants: 300 g/L.
      h. Sealant Primers for Nonporous Substrates: 250 g/L.
      i. Sealant Primers for Porous Substrates: 775 g/L.
      j. Other Adhesives and Sealants: 250 g/L.

C. Sheet Flashing: White, 60-mil-thick EPDM, partially cured or cured, according to application.

D. Bonding Adhesive: Manufacturer's standard, water based.

E. Splice Tape and Primer: Manufacturer’s standard, synthetic-rubber polymer primer and 3-inch wide minimum, white EPDM splice tape with release film.

F. Lap Sealant: Manufacturer's standard, single-component sealant, colored to match membrane roofing.

G. Water Cutoff Mastic: Manufacturer's standard butyl mastic sealant.

H. Metal Termination Bars: Manufacturer's standard, predrilled 6063-T6 extruded aluminum, approximately 1-inch by 1/8-inch thick; with anchors.

I. Fasteners: Factory-coated steel fasteners and metal or plastic plates complying with corrosion- resistance provisions in FM 4470, designed for fastening membrane to substrate, and acceptable to roofing system manufacturer.

J. Miscellaneous Accessories: Provide pourable sealers, preformed cone and vent sheet flashings, preformed inside and outside corner sheet flashings, reinforced EPDM securement strips, T-joint covers, in-seam sealants, termination reglets, cover strips, and other accessories.

K. Substrate Board: ASTM C1177/C1177M, glass-mat, water-resistant gypsum substrate, ½ - inch thick.
   1. Fasteners: Factory-coated steel fasteners and metal or plastic plates complying with corrosion-resistance provisions in FM 4470, designed for fastening substrate panel to roof deck.

L. Cover Board: ASTM C1177/C1177M, glass-mat, water-resistant gypsum substrate, 1/2 inch thick, factory primed.

M. Flexible Walkways: Factory-formed, nonporous, heavy-duty, solid-rubber, slip-resisting, surface-textured, white walkway pads, approximately 3/16 inch thick, and acceptable to EPDM roofing system manufacturer

PART 3 EXECUTION

3.01 SHIPMENT AND STORAGE

A. Product shall be shipped and stored in accordance with Section 016610.

B. Manufacturer shall provide Contractor's Spec Term with detailed recommendations and instructions for product storage.

C. Manufactured roofing materials shall be delivered in Manufacturers' original unopened containers or wrappings with labels intact and legible. Where materials are covered by a referenced Section, the containers shall bear the Section number, type, and class as applicable. Materials shall be stored on pallets and covered with canvas tarpaulins to keep them clean and dry. Polyethylene covering is not an acceptable method of protecting materials. Materials temporarily stored on the roof shall be located in approved areas and shall be distributed to stay within the indicated live load limits of the roof construction.

3.02 SUPPLIER'S FIELD SERVICES

A. Manufacturer shall provide field services in accordance with Section 01 60 00 Common Product Requirements and as further required within this Section.

B. Manufacturer shall provide assistance during product installation as required by the Contractor's Spec Term.

3.03 WORK SEQUENCE

A. Work shall be arranged to prevent use of newly constructed roofing for storage, walking surface, or equipment movement. If access is necessary, temporary walkways, platforms, or runways shall be provided to protect new roofing surfaces and flashings from mechanical damage.

3.04 INSPECTION

A. Contractor's Spec Term and installer shall examine the substrate and the conditions under which the EPDM roofing and base flashing Work is to be performed, and notify Design Professional's Spec Term, in writing, of unsatisfactory conditions. Do not proceed with the Work until unsatisfactory conditions have been corrected in a manner acceptable to Design Professional's Spec Term.

B. Examine substrates, areas, and conditions, with Installer present, for compliance with the following requirements and other conditions affecting performance of roofing system:
   1. Verify that roof openings and penetrations are in place and curbs are set and braced and that roof drain bodies are securely clamped in place.
   2. Verify that wood blocking, curbs, and nailers are securely anchored to roof deck at penetrations and terminations and that nailers match thicknesses of insulation. Fasteners shall the size and material recommended by the membrane roofing manufacturer.
   3. Verify that minimum concrete drying period recommended by roofing system manufacturer has passed.
   4. Verify that concrete substrate is visibly dry and free of moisture. Test for capillary moisture by plastic sheet method according to ASTM D4263.
   5. Verify that concrete curing compounds that will impair adhesion of roofing components to roof deck have been removed.

3.05 PREPARATION

A. Clean the substrate of dust, debris, substances, and interferences detrimental to the Work.

B. Fill voids, joints, and rough areas in the substrate with elastomeric sealant or other underlayment compound recommended by the EPDM roofing manufacturer.

C. Test the substrate for excessive moisture as recommended by the EPDM roofing manufacturer.

D. Prevent materials from entering and clogging roof drains and conductors and from spilling or migrating onto surfaces of other construction. Remove roof-drain plugs when no work is taking place or when rain is forecast.

E. Complete terminations and base flashings and provide temporary seals to prevent water from entering completed sections of roofing system at the end of the workday or when rain is forecast. Remove and discard temporary seals before beginning work on adjoining roofing.

3.06 INSTALLATION

A. General

1. Follow all applicable installation instructions and recommendations contained in the EPDM roofing manufacturer's written installation and product manuals and the information contained on approved Shop Drawings. Where Contractor's Spec Term requests to deviate from written installation and product manuals and approved Shop Drawings, all such deviations shall be submitted to Design Professional's Spec Term for approval along with EPDM roofing manufacturer's written agreement and a statement of acceptability for compliance with guaranteed construction.
2. Begin installation only in the presence of the EPDM roofing manufacturer's technical representative.
3. Cut sheets to the maximum size possible, in order to minimize seams and to accommodate contours of the deck. Do not seam within four feet of roof drains.
4. Clean all splices and lap areas using Manufacturer's recommended splice cleaner.
5. Lap sheets and bond joints using the seaming system recommended by the Manufacturer.
6. Cover top edges of each sheet at seams with uniform fillet of special sealant.

B. Adhered Membrane Roofing Installation

1. Adhere membrane roofing over area to receive roofing according to membrane roofing system manufacturer’s written instructions. Unroll membrane roofing and allow to relax before installing.
2. Start installation of membrane roofing in presence of membrane roofing system manufacturer’s technical personnel.
3. Accurately align membrane roofing and maintain uniform side and end laps of minimum dimensions required by Manufacturer. Stagger end laps.
4. Bonding Adhesive: Apply to substrate and underside of membrane roofing at rate required by the Manufacturer and allow to partially dry before installing membrane roofing. Do not apply to splice area of membrane roofing.
5. In addition to adhering, mechanically fasten membrane roofing securely at terminations, penetrations, and perimeters.
6. Apply membrane roofing with side laps shingled with slope of roof deck where possible.

7. Tape Seam Installation: Clean and prime both faces of splice areas, apply splice tape, and firmly roll side and end laps of overlapping membrane roofing according to Manufacturer's written instructions to ensure a watertight seam installation. Apply lap sealant and seal exposed edges of membrane roofing terminations.
8. Repair tears, voids, and lapped seams in roofing that does not comply with requirements.

C. Base Flashing Installation
1. Install sheet flashings and preformed flashing accessories and adhere to substrates according to membrane roofing system manufacturer's written instructions.
2. Apply bonding adhesive to substrate and underside of sheet flashing at required rate and allow to partially dry. Do not apply to seam area of flashing.
3. Flash penetrations and field-formed inside and outside corners with cured or uncured sheet flashing.
4. Clean splice areas, apply splicing cement, and firmly roll side and end laps of overlapping sheets to ensure a watertight seam installation. Apply lap sealant and seal exposed edges of sheet flashing terminations.
5. Terminate and seal top of sheet flashings and mechanically anchor to substrate through termination bars.

D. Flexible Walkways: Install walkway products in locations indicated. Adhere walkway products to substrate with compatible adhesive according to roofing system manufacturer's written instructions.

3.07 FIELD TESTING AND COMMISSIONING

A. Testing Agency: Engage a qualified independent testing agency to perform inspections.

B. After installing the EPDM roofing membrane, and all elastic sheet and flashing seams have been sealed, conduct in-place water retention tests.
1. Plug drains and flood roof with 2-inches of water above roof high points. Let water remain in-place for 24 hours. Do not add additional water during the time of the test and schedule testing during a period when precipitation is not predicted. If precipitation occurs during the time of the test, reconduct test when precipitation is not predicted during the time of the test. Calculate expected evaporation at temperatures, humidity and wind conditions occurring during the time of the tests.
2. Measure water remaining in place at the high point of roofs. Roof areas which demonstrate loss of water, that cannot be explained by loss due to evaporation, shall be inspected by a technical representative of the EPDM roofing manufacturer and the source of leaks determined and presented to the Owner's Spec Term and Design Professional's Spec Term as part of a field report which shall also make recommendations for remedial work. Where the source of leaks cannot be determined, the EPDM roofing shall be removed and replaced with new EPDM roofing at no additional cost to the Owner's Spec Term. All material and construction systems damaged by the results of this test shall be replaced with new, at no additional cost to the Owner's Spec Term.

3. After remedial repairs have been made and inspected by a technical representative of the EPDM roofing manufacturer and judged to be watertight, repeat the water retention test. If, this test shows that the EPDM roofing is still not retaining water according to expected results, remove the entire EPDM roofing and replace with new, at no additional cost to Owner's Spec Term.

C. Final Roof Inspection: Arrange for roofing system manufacturer's technical representative to inspect roofing installation on completion.

D. Repair or remove and replace components of membrane roofing system where inspections indicate that they do not comply with specified requirements.

E. Additional inspections, at Contractor's Spec Term's expense, will be performed to determine compliance of replaced or additional work with specified requirements

3.08 PROTECTION AND CLEANING

A. Protect membrane roofing system from damage and wear during remainder of construction period. When remaining construction will not affect or endanger roofing, inspect roofing for deterioration and damage, describing its nature and extent in a written report, with copies to Design Professional's Spec Term and the Owner's Spec Term.

B. Correct deficiencies in or remove membrane roofing system that does not comply with requirements, repair substrates and repair or reinstall membrane roofing system to a condition free of damage and deterioration at time of the Notice of Substantial Completion certificate issued for the Work and according to warranty requirements.

C. Clean overspray and spillage from adjacent construction using cleaning agents and procedures recommended by manufacturer of affected construction.

END OF SECTION

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SECTION 07 62 00

SHEET METAL FLASHING AND TRIM

PART 1 GENERAL

1.01 SCOPE OF WORK

A. Scope:
   1. Contractor's Spec Term shall provide all labor, materials, tools, equipment and incidentals as shown, specified and required to furnish and install sheet metal flashing and trim.
   2. The Work also includes:
      a. Providing openings in sheet metal flashing and trim to accommodate the Work under this and other Sections and building into the sheet metal flashing and trim all items such as sleeves, anchor bolts, inserts and all other items to be embedded in sheet metal flashing and trim for which placement is not specifically provided under other Sections.
   3. Types of products required include the following:
      a. Aluminum sheet flashing.
      b. Stainless steel sheet flashing.
      c. Formed metal coping.
      d. Miscellaneous flashing not supplied under other Sections.

B. Coordination:
   1. Review installation procedures under other Sections and coordinate the installation of items that must be installed with the sheet metal flashing and trim Work.
   2. Work advanced without sheet metal flashing and trim items that are specified to be cast-in-place or built-in-place as the Work advances, shall be stopped, demolished and rebuilt incorporating specified sheet metal flashing and trim Work, at no additional cost to Owner's Spec Term.

1.02 RELATED SECTIONS

A. Section 07 92 00 - Joint Sealants

1.03 REFERENCES STANDARDS

A. ASTM A666/A666M - Standard Specification for Annealed or Cold-Worked Austenitic Stainless Steel Sheet, Strip, Plate, and Flat Bar.

B. ASTM B29 - Standard Specification for Refined Lead.

C. ASTM B32 - Standard Specification for Solder Metal.

D. ASTM B749 - Standard Specification for Lead and Lead Alloy Strip, Sheet, and Plate Products.

E. ASTM D4586/D4586M - Standard Specification for Asphalt Roof Cement, Asbestos-Free.

F. NRCA (RM) - The NRCA Roofing Manual.

G. SMACNA (ASMM) - Architectural Sheet Metal Manual.

1.04 SUBMITTALS

A. Action Submittals:
   1. Procedures: Section 01 33 00.
   2. A copy of this specification section, with addendum updates included, and all referenced and applicable sections, with addendum updates included, with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements. Check marks (✓) shall denote full compliance with a paragraph as a whole. If deviations from the specifications are indicated, and therefore requested by the Contractor's Spec Term, each deviation shall be underlined and denoted by a number in the margin to the right of the identified paragraph, referenced to a detailed written explanation of the reasons for requesting the deviation. The Engineer shall be the final authority for determining acceptability of requested deviations. The remaining portions of the paragraph not underlined will signify compliance on the part of the Contractor's Spec Term with the specifications. Failure to include a copy of the marked-up specification sections, along with justification(s) for any requested deviations to the specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration.
   3. Shop Drawings:
      a. Drawings showing the manner of forming, jointing and securing flashings and trim. Show fully dimensioned joint details and waterproof connections to adjoining Work and details at obstructions and penetrations.
      b. Drawings showing the coordination. Provide detailed Shop Drawings showing large scale details of sections and profiles of all sheet metal flashing and trim to be used in the Work, with all items, including fastener locations, cleats and other miscellaneous accessories necessary to complete the Work, fully dimensioned, properly located, quantified and presented such that sequence of installation is acceptable to each roofing system and adjacent construction material installer.
         1) Product Data:
            a) Copies of manufacturer's specifications, installation instructions and general recommendations for sheet metal flashing and trim required. Include manufacturer's data substantiating that the materials comply with the requirements.

B. Informational Submittals:
   1. Procedures: Section 01 33 00.
   2. Manufacturers' certificates of compliance with specified industry standards.
   3. Manufacturer's Instructions: Manufacturer's installation instructions. Indicate by copy of transmittal form that installer has received copy of manufacturer's installation instructions.

1.05 QUALITY ASSURANCE

A. Installer Qualifications:
   1. Engage a single installer who is a recognized flashing and trim installer, skilled and experienced in the type of flashing and trim Work required and equipped to perform workmanship in accordance with recognized standards so that there will be undivided responsibility for the performance of the Work. Submit name and qualifications to Design-Engineer along with at least three successfully completed Projects including names and telephone numbers of owners, architects and engineers, responsible for the project and the approximate contract price for flashing and trim work.

B. Source Quality Control:
   1. Except as otherwise shown, comply with recommendations of the roofing manufacturer concerning the installation of flashing and trim that affects the roofing bond or warranty.

1.06 DELIVERY, STORAGE AND HANDLING

A. Delivery of Materials:
   1. Deliver sheet metal flashing and trim materials in manufacturer's original, unopened, and undamaged containers and rolls, with labels intact and legible, indicating compliance with approved Shop Drawings.
   2. Items delivered in broken, damaged, rusted, or unlabeled condition shall immediately be removed from Site and not offered again for approval by the Owner's Spec Term/Design Professional's Spec Term.

B. Storage of Materials:
   1. Store materials in an area undercover and protected from construction traffic.
   2. Store materials in same package in which they were shipped, off the ground and on platforms protected from dirt and other contamination.
   3. Store in a manner which does not permit water to remain on sheet metal flashing and trim materials and system components.

C. Handling of Materials:
   1. Protect sheet metal flashing and trim from dents, scratches, warps and bends.
   2. Remove strippable protective film, immediately proceeding installation of each system component.

1.07 JOB CONDITIONS

A. Scheduling:
   1. Do not proceed with sheet metal flashing and trim Work until curb and substrate construction, cant strips, blocking, reglets and other construction to receive the Work is completed.
   2. Deliver materials to the Site in sufficient quantities to ensure uninterrupted progress of the Work.

3. Schedule the installation of sheet metal flashing and trim to coincide with the installation of roofing, waterproofing, drains, piping, blocking, nailers, reglets, framing at openings, curbs, parapets and other adjoining and substrate Work.
4. Proceed with and complete the Work only when materials, equipment and knowledgeable tradesmen, required for the installation of sheet metal flashing and trim, are at the Site and are ready to follow, and integrate sheet metal flashing and trim Work with roofing Work, in order to maintain watertight conditions.

1.08 WARRANTY

A. Provide reglet and counterflashing manufacturer's five-year warranty against defects and workmanship.

PART 2 PRODUCTS

2.01 SYSTEM PERFORMANCE

A. Performance Criteria:
1. Sheet metal flashing and trim shall be permanently watertight, and not deteriorate in excess of manufacturer's published limitations.
2. Comply with fabrication details recommended by FM, SMACNA, NRCA and the requirements of the sheet metal flashing and trim manufacturer, and as shown on approved Shop Drawings.

2.02 MATERIALS

A. Sheet Metal Flashing and Trim:
1. Stainless Steel Sheet metal flashing and trim: Provide 26 gage sheet stainless steel, Type 316, complying with ASTM A666/A666M, with No. 2D dead soft, fully annealed finish, unless required to be harder temper for proper forming and performance for application indicated.
2. Lead Sheet metal flashing and trim: Provide sheet formed from common desilverized pig lead complying with ASTM B29 and ASTM B749; weighing 6.0 pounds per square foot.

B. Embedded Sheet Flashing:
1. Refer to Section 04 20 00 - Unit Masonry.

C. Flashing Reglets:
1. General:
a. Provide snap-lock type reglets of Type 304 stainless steel, 0.020-inches minimum thickness.
b. Provide reglets that engage counterflashing by use of a snap-lock or spring-lock profile. System shall employ only mechanical interlocking features for securing counterflashing in reglet, without the need for clips or screws.
c. Provide manufacturer's standard Type 304 stainless steel spring-lock profile flashing, 5-1/8-inches high, designed to incorporate a positive air break and to engage spring-lock reglet flange.
d. Provide reglets with 1-inch end laps and spring-lock flashing with 3-inch end laps.

2. Built-In-Place Masonry Reglets: Provide built-in-place reglets for masonry installation with top flange 4-inches wide to penetrate the first wythe of brick.
    a. Provide reglets without exposed fasteners of any kind. Provide engagement flange 1-1/8-inch high by 1/2-inch wide with snap-lock profile designed to pressure-lock counterflashing in place.
    b. Products and Manufacturers: Provide one of the following:
        1) Type MA-4 Masonry Reglet by Fry Reglet Corporation.
        2) or approved equal.

D. Miscellaneous Materials:
1. Burning Rod for Lead: Same composition as lead sheet.
2. Solder for Stainless Steel: ASTM B32, 60 percent tin and 40 percent lead alloy grade 60A, used with an acid flux of the type recommended by the stainless steel manufacturer. Use a non-corrosive rosin flux over tinned surfaces.
3. Stainless Welding Rods: Type recommended by stainless steel sheet manufacturer for the type of metal sheets furnished.
4. Nails, Screws and Rivets: Same material as flashing sheet, or as recommended by manufacturer of flashing sheet.
5. Cleats: Same metal and gage as sheet being anchored, 2-inches wide, punched for two anchors.
6. Bituminous Coating: SSPC-Paint 12, cold-applied solvent-type bituminous mastic coating for application in dry film thickness of 15-mils per coat.
7. Sealants: Refer to Section 07 92 00 - Joint Sealants.
8. Roofing Cement: Provide a medium to heavy trowel-grade, cut-back asphalt mastic roof cement reinforced with non-asbestos fibers, and containing petroleum solvents and special mineral stabilizers, complying with ASTM D4586/D4586M, Type II.
9. Base Flashing Felts: Asphalt-coated, polyester/glass scrim reinforced flashing sheet or as recommended by the manufacturer of the built-up bituminous roofing.

2.03 FABRICATION

A. Fabricated Metal Flashing: Shop-fabricate metal sheet metal flashing and trim to comply with profiles and sizes shown, and to comply with manufacturer's recommended details. Except as otherwise shown or specified, provide soldered flat-lock seams, and fold back metal to form a hem on the concealed side of exposed edges. Comply with metal producers' recommendations for tinning, soldering and cleaning flux from metal.

B. Where fabricator does not recommend grinding welds smooth, comply with SMACNA formed metal details requiring double lock seamed construction.

PART 3 EXECUTION

3.01 INSPECTION

A. Examine the substrate and the conditions under which the sheet metal flashing and trim Work is to be performed, and notify Design Professional's Spec Term, in writing, of unsatisfactory conditions. Do not proceed with sheet metal flashing and trim Work until unsatisfactory conditions have been corrected in a manner acceptable to the Owner's Spec Term/Design Professional's Spec Term.

3.02 PREPARATION

A. Before installing sheet metal flashing and trim, verify shapes, and dimensions to be covered.

B. Prepare substrates as recommended by the sheet metal manufacturer.

3.03 INSTALLATION

A. General:

1. Separate dissimilar metals from each other by painting each metal surface in the area of contact with a heavy application of bituminous coating, or by other permanent separation as recommended by the manufacturers of the dissimilar metals. Comply with the following:
    a. Separate stainless steel from dissimilar metals, including regular steel and iron, and from cementitious materials by a course of roofing felt wherever possible. Where felt application is not possible, coat the stainless steel or the other material with a 15-mil bituminous coating. Where felt is applied under sheets which will be soldered or welded, cover felt with a course of building paper before installing stainless steel. Comply with manufacturer's recommendations for other forms of protection of the stainless steel against corrosion.
2. Provide thermal expansion for running trim, flashing, valleys, and other items exposed for more than 15 feet-0 inches continu ous length. Maintain a watertight installation at expansion seams. Locate expansion seams as shown or, if not shown, at the following maximum spacing for each general flashing use:
    a. Valleys: Midway between drains (at high points in slopes), but in no case more than 30 feet-0 inches apart, except as otherwise shown.
    b. Sheet metal flashing and trim: At 10 feet-0 inch intervals and 2 feet-0 inch each side of corners and intersections.
3. Fabricate and install Work with lines and corners of exposed units true and accurate. Form exposed faces flat and free of buckles, excessive waves and avoidable tool marks, considering the temper and reflectivity of the metal. Provide uniform, neat flat-locked seams with minimum exposure of solder, welds and sealant. Except as otherwise shown, fold back the sheet metal to form a hem on the concealed side of exposed edges. All exposed edges of all sheet metal flashing shall be hemmed not less than 1/2-inch wide.
4. Conceal fasteners and expansion provisions wherever possible in exposed Work, and locate so as to minimize the possibility of leakage. Cover and seal Work as required for a watertight installation.
    a. Provide cleat-type anchorages for metal flashings and trim wherever practical, arranged to relieve stresses from building movement, and thermal expansion and contraction.
5. On vertical surfaces lap two-piece flashings a minimum of 4-inches.
6. On sloping surfaces, for slopes of not less than 6-inches in 12-inches, lap unsealed flashings a minimum of 6-inches. For slopes less than 6-inches in 12-inches use soldered flat locked seams.
7. For embedment of metal flashing flanges in roofing or composition flashing or stripping, extend flanges for a minimum of 4-inches embedment.

B. Installation of Stainless Steel Sheet Metal Flashing and Trim:

1. Tin the edges of plain stainless steel to be soldered, for a width of 1-1/2-inches, using solder for stainless steel and acid flux. Remove every trace of acid flux residue from the metal promptly after tinning or soldering.
2. Where welded joints are shown, provide upturned, 1/2-inch wide hooked flanges, and weld between adjoining sheets; lay seam flat.

C. Installation of Reglets and Counterflashing:

1. Install reglets for flashing and other related Work where shown to be built into unit masonry construction.
2. Install counterflashing with positive pressure against base flashing and reglet and with air break at mid-point to prevent capillary action. No screws or exposed fasteners shall be permitted in the finished Work except those required at each pre-punched hole for surface-mounted reglet attachment.
3. End lap counterflashing horizontally a minimum of 3-inches.
4. Overlap base flashing with counter flashing a minimum of 4-inches vertically and fold lower edge back on itself for 1/2-inch.

3.04 ADJUSTMENT AND CLEANING

A. Protect sheet metal flashing and trim until Final Acceptance of the Work.

B. Do not permit workmen, or others, to step directly on flashing sheets in place, or to place or move equipment over sheet metal flashing and trim surfaces. Protect surfaces during installation of permanent covering work and adjoining Work.

C. Neutralize excess flux as the Work progresses with five percent to percent washing soda solution and rinse thoroughly.

D. Clean exposed surfaces of every substance which is visible or might cause corrosion or prevent uniform oxidation of the metal surfaces. Exercise extreme care to remove fluxes and ferrous metal particles, including welding splatter and grinding dust.

END OF SECTION

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SECTION 07 92 00

JOINT SEALANTS

PART 1 GENERAL

1.01 DESCRIPTION

A. This section specifies sealants as shown on the Contract Drawings.

1.02 QUALITY ASSURANCE

A. References:

1. This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.
2. Unless otherwise specified, references to documents shall mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid (or on the effective date of the Agreement if there were no Bids). If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued. Where document dates are given in the following listing, references to those documents shall mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, discontinued or replaced.

Reference	Title
FEDSPEC TT-S-00230C	Sealing Compound: Elastomeric Type, Single Component
FEDSPEC TT-S-00227E	Sealing Compound: Elastomeric Type, Multi-Component

PART 2 PRODUCTS

2.01 POLYURETHANE SEALANT

A. Acceptable Products:

1. Acceptable products shall be Sikaflex by Sika Chemical Corporation, Vulkem by Mameco International, U-Seal Joint Sealant by Burke Company, or Rubber Calk by Products Research and Chemical Corporation.

B. General:

1. Polyurethane sealants shall conform to FEDSPEC TT-S-0230C for one-component systems and FEDSPEC TT-S-00227E for two-component systems. Polyurethane sealant shall be one of the following two types.
   a. Self-Leveling:
      1) Self-leveling polyurethane sealant shall be Type I, Class A as specified by the FEDSPECs referenced above.

b. Nonsag:
    1) Nonsag polyurethane sealant shall be Type II, Class A as specified by the FEDSPECs referenced above.

C. Primer:
    1. Primer shall be as recommended by the sealant manufacturer.

D. Backer Rod or Backer Tape:
    1. Backer rod shall be open cell polyethylene or polyurethane foam. Rod shall be cylindrical unless otherwise specified. Backer tape shall be polyethylene or polyurethane with adhesive on one side.

2.02 MASTIC SEALANT

A. General:
    1. Mastic joint sealant shall consist of a blend of refined asphalts, resins and plasticizing compounds, reinforced with fiber. Sealant shall be compatible with joint fillers and shall be pressure grade.

B. Primer:
    1. Primer shall be as recommended by the mastic sealant manufacturer.

2.03 PRODUCT DATA

A. The following information shall be provided in accordance with Section 01 33 00:
    1. Manufacturer's product data showing conformance to the specified products.
    2. Manufacturer's recommendations for storage, handling and application of sealants and primers.

PART 3 EXECUTION

3.01 GENERAL

A. Sealants and primers shall be applied according to the sealant manufacturer's recommendations. Polyurethane sealants shall be used on all expansion joints and specified construction joints.

B. Joints and spaces to be sealed shall be clean, dry and free of dust, loose mortar, concrete and plaster. Additional preparation of joints and spaces shall be provided in accordance with manufacturer's recommendations. Primer shall be applied only to the surfaces that will be covered by the sealant.

3.02 POLYURETHANE SEALANTS

A. General:
    1. Nonsag polyurethane sealants shall be used on vertical joints. Self-leveling polyurethane sealants shall be used on horizontal joints.

B. Joint Dimensions:

1. Unless otherwise specified, joints and spaces to be filled shall be constructed to the following criteria. Joints and spaces shall have a minimum width of 1/4 inch and a maximum width of 1 inch. The depth of the sealant shall be one-half the width of the joint, but in no case less than 1/4 inch deep. Sealant depth shall be measured at the point of smallest cross section. When joints exceed the depth requirements, backing rod shall be inserted to provide the joint depth specified. If the joint sealant depth is within the specified tolerances, backer tape shall be placed in the bottom of the joint.

3.03 MASTIC SEALANT

A. Joint Dimensions:

1. Joints to be sealed shall be 2 inches deep, 1 inch wide at the top, and 3/4 inch wide at the base.

END OF SECTION

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SECTION 08 11 13.13

STANDARD HOLLOW METAL DOORS AND FRAMES

PART 1 GENERAL

1.01 DESCRIPTION

A. This section specifies steel doors and steel door frames.

1.02 REFERENCE STANDARDS:

A. ANSI A115.1 - Preparation for Mortise Locks for 1-3/8 & 1-3/4 In. Standard Steel Doors and Frames.

B. ANSI A115.2 - Preparation of Bored Locks for 1 3/8 & 1 3/4 Doors.

C. ANSI A115.4 - Preparation for Lever Extension Flush Bolts.

D. ANSI A115.7 - Standard Steel Door and Steel Frame Preparation for Floor Closers Light Duty, Center Hung, Single or Double Acting; Center Hung, Single of Double Acting; Offset Hung, Single Acting.

E. ANSI A151.1 - Test Procedure and Acceptane Criteria for Physical Endurance.

F. ANSI/SDI A250.6 - Recommended Practice for Hardware Reinforcing on Standard Steel Doors and Frames.

G. ANSI/SDI A250.8 - Specifications for Standard Steel Doors and Frames (SDI-100).

H. ANSI/SDI A250.11 - Recommended Erection Instructions for Steel Frames.

I. ASTM A526/A526M - Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) by the Hot-Dip Process, Commercial Quality.

J. ASTM C578 - Standard Specification for Rigid, Cellular Polystyrene Thermal Insulation.

K. ASTM C591 - Standard Specification for Unfaced Preformed Rigid Cellular Polyisocyanurate Thermal Insulation.

L. ASTM D2863 - Standard Test Method for Measuring the Minimum Oxygen Concentration to Support Candle-Like Combustion of Plastics (Oxygen Index).

M. DOD-P-21035A - Paint, High Zinc Dust Content, Galvanizing Repair.

N. NFPA 80 - Standard for Fire Doors and Other Opening Protectives.

O. NFPA 252 - Standard Methods of Fire Tests of Door Assemblies.

P. SDI 111 - Recommended Details for Standard Steel Doors, Frames, Accessories and Related Components.

Q. UL 10B - Standard for Fire Tests of Door Assemblies.

R. This section contains references to the above documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.

S. Unless otherwise specified, references to documents shall mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid (or on the effective date of the Agreement if there were no Bids). If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued. Where document dates are given in the following listing, references to those documents shall mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, discontinued or replaced.

1.03 QUALITY ASSURANCE

A. Certificates of Compliance: Manufacturers' certificates shall be provided attesting that doors, frames, and accessories meet the specified requirements. The grade and model number of each door shall be included.

1.04 SUBMITTALS

A. The following information shall be provided in accordance with Section 01 33 00:
   1. A copy of this specification section, with addendum updates included, and all referenced and applicable sections, with addendum updates included, with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements. Check marks (✓) shall denote full compliance with a paragraph as a whole. If deviations from the specifications are indicated, and therefore requested by the Contractor's Spec Term, each deviation shall be underlined and denoted by a number in the margin to the right of the identified paragraph, referenced to a detailed written explanation of the reasons for requesting the deviation. The Design Professional's Spec Term shall be the final authority for determining acceptability of requested deviations. The remaining portions of the paragraph not underlined will signify compliance on the part of the Contractor's Spec Term with the specifications. Failure to include a copy of the marked-up specification sections, along with justification(s) for any requested deviations to the specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration.
   2. Shop drawings containing the following information:
      a. Elevations of each door type
      b. Size of doors and frames
      c. Metal gages
      d. Details of door and frame construction
      e. Methods of anchorage
      f. Glazing details

g. Weatherstripping
h. Provisions for and location of hardware
i. Details of installation
j. Schedule showing location of each door, frame, and swing of door

1.05 DELIVERY AND STORAGE

A. Doors, frames, and accessories shall be delivered undamaged and with protective wrappings or packaging. Doors and frames shall be stored on platforms under cover in clean, dry, ventilated, and accessible locations, with 1/4-inch airspace between doors. Damp or wet packaging shall be removed immediately and affected surfaces wiped dry. Damaged materials shall be replaced with new materials.

PART 2 PRODUCTS

2.01 STEEL DOORS

A. General:
1. Steel doors shall be 1-3/4 inches thick and conform to ANSI/SDI A250.8 unless otherwise specified. Doors shall be either hollow steel construction or composite construction and shall be prepared to receive hardware specified in Section 08 71 00 - Door Hardware.

B. Hollow Steel Doors:
1. Unless otherwise specified, hollow steel doors shall be fabricated from cold rolled steel and shall be extra heavy duty doors conforming to ANSI/SDI A250.8, Grade III, Model 3, of the sizes and designs specified. Face sheets, as well as lock and hinge edges, shall have a smooth, seamless and unbroken surface, with top and bottom edges closed flush to the door face sheets. No inverted channels will be allowed.
2. Unless otherwise specified, inner structure shall be formed as a unitized grid composed of minimum 18 gage steel vertical and horizontal channels with rigidized webbing. The grid shall be unitized by double projection welding at each junction, and the applicable hardware reinforcements attached by multiple welds. The grid shall form the flush top and bottom sections of the door. Hinge and lock accommodations shall be preformed as an integral part of the continuous vertical member forming the periphery of the unitized grid. The back-up reinforcement of hinges and lock shall extend not less than 5 inches into the interior of the unitized grid and join the parallel inner vertical member of the grid structure. Inside surfaces of the face sheets shall be coated with a synthetic resin based sound deadener. The face sheets shall be attached to the grid assembly by double projection multiple series welds.

C. Insulated Steel Door Systems:

1. Insulated steel doors, where specified, shall have a full door thickness of polystyrene or polyurethane insulation to provide an overall door insulation value of R-2.70. Doors shall have face sheets, edges, and frames of galvanized steel; magnetic weatherstripping; nonremovable-pin hinges; thermal-break aluminum threshold; and vinyl door bottom. Doors and frames shall receive phosphate treatment, rust-inhibitive primer, and baked acrylic enamel finish. Doors shall have been tested in accordance with ANSI A151.1 and shall have met the requirements for Level C. Doors shall be prepared to receive hardware specified in Section 08 71 00 - Door Hardware.

2.02 STANDARD STEEL FRAMES

A. General:

1. Steel frames shall conform to ANSI/SDI A250.8, shall be of the sizes and shapes specified, and unless otherwise specified, shall be fully welded unit type frames. Steel frames shall be provided for doors. Pack with mineral wool insulation at exterior conditions.

B. Welded Frames:

1. Frame faces shall be continuously welded at corner joints. Stops and rabbets shall be mechanically interlocked or continuously welded. All welds shall be ground smooth. Frames shall be mortised and reinforced with heavy gage reinforcements for hinges and lock strikes. Steel spreaders to ensure proper alignment of the frame shall be used and shall remain in place until the adjacent wall construction is complete.

C. Anchors:

1. General:
    a. Steel anchors shall be provided to secure the frame to adjoining construction. Anchors shall be zinc-coated or painted with rust-inhibitive paint, not lighter than 18 gage.
2. Wall Anchors:
    a. A minimum of three anchors shall be provided for each jamb. Anchors shall be located opposite top and bottom hinges and midway between.
        1) Anchors for masonry work shall be corrugated or perforated steel straps or 3/16-inch diameter steel wire, adjustable or T-shaped.
        2) Anchors for stud partitions shall be welded or otherwise securely fastened to backs of frames. Anchors shall be designed and fastened to wood studs with nails, to closed steel studs with sheet metal screws, and to open steel studs by wiring or welding.
        3) Frames shall be secured to previously placed concrete or masonry with expansion bolts in accordance with SDI 111-F.
        4) Anchors for solid plaster partitions shall be secured solidly to back of frames and tied into the lath. Adjustable top strut anchors shall be provided on each side of frame for fastening to structural members or ceiling construction above. Size and type of strut anchors shall be as recommended by the frame manufacturer.

3. Floor Anchors:
    a. Floor anchors drilled for 3/8-inch anchor bolts shall be provided at bottom of each jamb member. Where floor fill occurs, bottom of frames shall be terminated at the indicated finished floor levels and supported by adjustable extension clips resting on and anchored to the structural slabs.

2.03 LOUVERS, ASTRAGALS, AND MOLDINGS

A. Louvers:
    1. Louvers, where specified, shall be stationary sightproof type for interior doors or metal frames and shall be inverted Y type for exterior doors. Louver blades shall be welded or tenoned to frame and the entire louver assembly fastened to the door with moldings. Moldings on the room or nonsecurity side of the door shall be detachable; moldings on the security side of the door shall be an integral part of the louver. Louvers shall be formed of 20-gage steel for interior doors and panels and of 16-gage steel for exterior doors and panels. Louvers for exterior doors shall have steel-framed 18 by 16 aluminum wire cloth mesh insect screens rigidly secured to louvers to permit ready removal. Louvers, before screening, except for exterior doors, shall have a minimum of 35 percent net-free opening. Louvers for exterior doors shall have a minimum of 30 percent net-free opening.

B. Astragals:
    1. Pairs of exterior steel doors which will not have aluminum astragals or removable mullions shall have overlapping steel astragals provided with the doors.

C. Moldings:
    1. Moldings shall be provided around glass and louvers; moldings shall be nonremovable on the outside of exterior doors and on the corridor side of interior doors. Other moldings may be stationary or removable. Inside moldings shall be secured to the stationary moldings, or snap-on moldings provided. Muntins shall interlock at intersections and shall be fitted and welded to stationary moldings.

2.04 PLASTIC FOAM CORES

A. Plastic foam cores shall be:
    1. Rigid polyurethane foam conforming to ASTM C591, Type 1 or 2, foamed-in-place or in board form, with an oxygen index of not less than 22 percent when tested in accordance with ASTM D2863.
    2. Rigid polystyrene foam board conforming to ASTM C578, Type I or II.

2.05 WEATHERSTRIPPING

A. Weatherstripping shall be as specified in Section 08 71 00 - Door Hardware.

2.06 HARDWARE PREPARATION

A. Doors and frames to receive finish hardware shall be reinforced, drilled, and tapped for hardware in accordance with the applicable requirements of ANSI/SDI A250.6 and ANSI A115.1, ANSI A115.2, ANSI A115.4, and ANSI A115.7. Drilling and tapping for surface-applied hardware shall be done in the field, but additional reinforcing for surface-applied hardware shall be built into the door at the factory. Hardware shall be located in accordance with the requirements of ANSI/SDI A250.8, as applicable.

2.07 FINISHES

A. Hot-Dip Zinc-Coated and Factory-Primed Finish:
   1. Where specified, doors and frames shall be fabricated from galvanized steel, ASTM A526/A526M, Coating Designation G60 or A60 (galvannealed). Damaged zinc-coated surfaces shall be repaired by the application of zinc dust paint conforming to DOD-P-21035A. Zinc-coated surfaces shall be phosphate treated and factory primed as specified in ANSI/SDI A250.8.

2.08 FABRICATION AND WORKMANSHIP

A. Finished doors and frames shall be strong and rigid, neat in appearance, and free from defects, waves, scratches, cuts, dents, ridges, holes, warp, and buckle. Molded members shall be clean cut, straight, and true, with joints coped or mitered, well formed, and in true alignment. Exposed welded and soldered joints shall be ground smooth. Door frame sections shall be designed for use with the wall construction specified. Corner joints shall be well formed and in true alignment. Fastenings shall be concealed where practicable. On wraparound frames for masonry partitions, a throat opening shall be provided 1/8 inch larger than the actual masonry thickness. Frames in exposed masonry walls or partitions shall be designed to allow sufficient space between the inside back of trim and masonry to receive caulking compound.

2.09 PRODUCT DATA

A. The following information shall be provided in accordance with Section 01 33 00:
   1. Detail specifications and instructions for installation, adjustments, cleaning, and maintenance.
   2. Certificates of compliance specified in paragraph 1.02 Certificates of Compliance.

PART 3 EXECUTION

3.01 INSTALLATION

A. Frames:

1. Frames shall be set in accordance with ANSI/SDI A250.11, and plumbed, aligned, and braced securely until permanent anchors are set. Bottoms of frames shall be anchored with expansion bolts or powder-actuated fasteners. Wall anchors shall be built in or secured to adjoining construction. Where frames require ceiling struts or overhead bracing, frames shall be anchored to the struts or bracing. Frames shall be backfilled with mortar. When an additive is provided in the mortar, inside of frames shall be coated with corrosion-inhibiting bituminous material. For frames to be installed in exterior walls and to be filled with mortar or grout, the stops shall be filled with strips of rigid insulation to keep the grout out of the stops and to facilitate installation of stop-applied head and jamb seals.

B. Doors:

1. Doors shall be hung in accordance with clearances specified in ANSI/SDI A250.8. After erection and glazing, hardware shall be cleaned and adjusted.

3.02 PROTECTION

A. Doors and frames shall be protected from damage, and damaged doors and frames repaired prior to completion and acceptance of the project or replaced with new, as directed. Rusted frames shall be wire brushed until all rust is removed, cleaned thoroughly, and applied with an all-over coat of rust-inhibitive paint of the same type used for shop coat.

3.03 CLEANING

A. Upon completion, exposed surfaces of doors and frames shall be cleaned thoroughly. Mastic smears and other unsightly marks shall be removed.

END OF SECTION

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SECTION 08 71 00

DOOR HARDWARE

PART 1 GENERAL

1.01 SCOPE OF WORK

A. Scope:
   1. Contractor's Spec Term shall provide all labor, materials, tools, equipment and incidentals as shown, specified and required to furnish and install finish hardware. Furnish finish hardware for all doors in compliance with these Specifications herein.
   2. Extent of finish hardware is specified. Finish hardware is defined to include all items known commercially as finish hardware, except special types of unique and non-matching hardware specified in the same Section as the door and doorframe.
   3. Types of products required include the following:
      a. Mortise hinges.
      b. Overhead, surface-mounted, door closers.
      c. Dust-proof strikes.
      d. Door pulls, push plates and protection armor plate.
      e. Stripping and seals.
      f. Thresholds.
      g. Silencers.
      h. Floor stops.
      i. Wall stops.
      j. Protection Armor.
      k. Miscellaneous items and accessories for a complete installation functioning in compliance with the requirements of governing authorities having jurisdiction at the Site.

B. Coordination:
   1. Review installation procedures under other Sections and coordinate the installation of items that must be installed with, or before, the finish hardware.
   2. Coordinate the Work of other Sections to provide clearances and accurate positioning of recessed or cast-in-place items.

1.02 REFERENCE STANDARDS

A. ANSI A115.1 - Preparation for Mortise Locks for 1-3/8 & 1-3/4 In. Standard Steel Doors and Frames.

B. BHMA A156.1 - Standard for Butts and Hinges.

C. BHMA A156.4 - Door Controls - Closers.

D. BHMA A156.6 - Standard for Architectural Door Trim.

E. BHMA A156.7 - Template Hinge Dimensions.

F. BHMA A156.16 - Auxiliary Hardware.

G. BHMA A156.18 - Standard for Materials and Finishes.

H. BHMA A156.21 - Thresholds.

I. BHMA A156.22 - Standard for Gasketing.

J. BHMA A156.115 - Hardware Preparation In Steel Doors And Steel Frames.

K. DHI (H&S) - Sequence and Format for the Hardware Schedule.

L. DHI TDH-008 - Recommended Locations for Architectural Hardware for Doors Installed in Custom Steel Frames.

M. DHI TDH-009 - Recommended Locations for Architectural Hardware for Standard Steel Doors and Frames.

N. ICC A117.1 - Accessible and Usable Buildings and Facilities.

O. NAAMM HMMA 830 - Hardware Selection for Hollow Metal Doors and Frames.

P. NFPA 80 - Standard for Fire Doors and Other Opening Protectives.

Q. NFPA 252 - Standard Methods of Fire Tests of Door Assemblies.

R. SDI 109 - Hardware for Standard Steel Door and Frames.

S. SDI 118 - Basic Fire Door, Fire Door Frame, Transom/Sidelight Frame, and Window Frame Requirements.

T. UL (DIR) - Online Certifications Directory.

U. UL 10B - Standard for Fire Tests of Door Assemblies.

V. UL 305 - Standard for Panic Hardware.

W. Public Law 101-336 - Appendix A to Title 28 Code of Federal Regulations Part 36 (Americans with Disabilities Act Accessibility Guidelines for Buildings and Facilities - ADAAG)

X. The references listed above are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.

Y. The references listed below indicate those documents in effect at the time of Advertisement for Bids, Invitation to Bid, or on the effective date of the Agreement if there were no Bids. Where documents are referenced in applicable local, state, or federal codes, use the version reference by date in the individual code. If referenced documents are not specifically identified in the applicable code(s), reference to those documents

shall indicate the latest version of the documents available at the time of Advertisement for Bids. If referenced documents have been discontinued by the issuing organization, reference to those documents shall mean the latest version of replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued. When document dates are given in the following listing that are not specifically referenced in an applicable code, references to those documents shall mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, discontinued or replaced. For questions, refer to Design Professional's Spec Term.

1.03 QUALITY ASSURANCE

A. Manufacturer's Qualifications:
   1. Provide finish hardware and accessories manufactured by firms specializing in the production of this type of Work and complying with specified standards of ANSI, BHMA, DHI, NFPA, HMMA, SDI and UL.
   2. Provide finish hardware from manufacturers who are members of BHMA and participate in BHMA certification programs.

B. Installer's Qualifications:
   1. The finish hardware installer shall have in his employ an architectural hardware consultant. The architectural hardware consultant shall be a member of the Door and Hardware Institute, (DHI), who has passed the DHI certification examine and successfully completed an apprenticeship program. The architectural hardware consultant shall be responsible for preparing finish hardware schedules and Shop Drawings and be present at the Site for the purpose of checking and supervising the Work of the installer during the time of installation and adjustment of the finish hardware Work, and shall prepare a written field report on status of completed finish hardware installation as specified.
   2. Submit name and qualifications of the installer to the Design Professional's Spec Term.

C. Requirements of Regulatory Agencies:
   1. Provide finish hardware for fire-resistance-rated openings in compliance with NFPA 80.
   2. Provide only finish hardware that has been tested, listed and labeled by UL for the types and sizes of doors required, and complies with the requirements of the door and doorframe labels.
   3. Modify features of finish hardware items specified and provide additional accessories and features as required to meet UL and NFPA requirements, at no additional cost to the Owner's Spec Term.

D. Codes: Comply with applicable requirements of codes.

E. Source Quality Control:
   1. Obtain each type of finish hardware item from only one manufacturer.
   2. Provide finish hardware schedule, for submission to, and for approval by the Design-Design Professional's Spec Term, prepared in compliance with DHI standards.

3. Comply with specified BHMA standards.

1.04 SUBMITTALS

A. Action Submittals:
   1. Procedures: Section 01 33 00.
   2. A copy of this specification section, with addendum updates included, and all referenced and applicable sections, with addendum updates included, with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements. Check marks (☐) shall denote full compliance with a paragraph as a whole. If deviations from the specifications are indicated, and therefore requested by the Contractor's Spec Term, each deviation shall be underlined and denoted by a number in the margin to the right of the identified paragraph, referenced to a detailed written explanation of the reasons for requesting the deviation. The Design Professional's Spec Term shall be the final authority for determining acceptability of requested deviations. The remaining portions of the paragraph not underlined will signify compliance on the part of the Contractor's Spec Term with the specifications. Failure to include a copy of the marked-up specification sections, along with justification(s) for any requested deviations to the specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration.

B. Informational Submittals:
   1. Procedures: Section 01 33 00.
   2. Manufacturer' certificates of compliance with specified industry standards.

C. Samples:
   1. Actual unit of each finish hardware item specified incorporating all standard and special features and finishes specified, demonstrated and identified by manufacturer's representative to the Design Professional's Spec Term. Samples shall be presented at time of Shop Drawing submittal, as Design Professional's Spec Term will not review or approve Shop Drawings without concurrent sample submissions.
   2. Approved samples may be incorporated into the finish hardware Work.
   3. Design Professional's Spec Term's review will be for appearance and for general compliance with required features. Compliance with all other requirements is the responsibility of Contractor's Spec Term.

D. Shop Drawings:
   1. Copies of manufacturer's data for each item of finish hardware. Include whatever information may be required to show compliance with specified requirements and include instructions for installation and for maintenance of operating parts and exposed finishes. Include mounting heights and locations for each item of finish hardware. Provide Design Professional's Spec Term with latest complete technical catalogue of all available finish hardware manufactured by proposed manufacturers, even if manufacturer specified by Design Professional's Spec Term is submitted by Contractor's Spec Term to perform the Work. Furnish templates to fabricators of other Work, which is to receive finish hardware.
   2. Copies of the Finish Hardware Schedule in the manner and format specified, complying with the actual construction Progress Schedule requirements (for each

draft). Include explanation of abbreviations, symbols, and codes used to present scheduled information.

a. Prepare and submit Finish Hardware Schedule in compliance with HDI standards.

3. Based on the finish hardware requirements specified, organize the final Finish Hardware Schedule into "hardware sets," indicating complete designation of every item required for each door or opening. Furnish initial draft of schedule at the earliest possible date, in order to facilitate the fabrication of other Work (such as hollow metal frames) which may be critical in the Project Schedule. Furnish final draft of schedule after Samples, manufacturer's data sheets, coordination with Shop Drawings for other Work, delivery schedules and similar information have been completed and accepted.
4. Include a separate key schedule, showing clearly how Owner's Spec Term's final instructions on keying of locks have been fulfilled.
5. Finish Hardware Schedules are intended for coordination of the Work. Review and acceptance by Design Professional's Spec Term does not relieve Contractor's Spec Term of responsibility to fulfill the requirements as shown and specified.
6. Installer's qualifications.
7. Maintenance Manual: Upon completion of the Work, furnish five copies of detailed maintenance manuals, including the following information:
   a. Product name and manufacturer.
   b. Name, address, e-mail address and telephone number of manufacturer and local distributor.
   c. Detailed procedure for routine maintenance and cleaning.
   d. Detailed procedures for repairs such as dents, scratches and staining.
   e. Parts identification manual and maintenance manuals for each piece of finish hardware.

E. Test Reports: Submit for approval certified independent laboratory test reports for BHMA certification program and certification tests for each type of product specified.

1.05 DELIVERY, STORAGE AND HANDLING

A. Packing, Shipping, Handling and Unloading:
   1. Deliver materials to the Site to ensure uninterrupted progress of the Work. Deliver anchor bolts and anchorage devices which are to be embedded in cast-in-place concrete in ample time to prevent delay of that Work.
   2. Deliver all items of finish hardware in manufacturer’s original, undamaged packages, bearing accurate representation of the item within each package.
   3. Pack each piece of finish hardware separately, complete with screws, keying, instructions and templates, tagged to correspond with items submitted on approved Shop Drawings and as specified.

B. Storage and Protection:
   1. Store materials to permit easy access for inspection and identification. Keep all material off the ground, using pallets, platforms, or other supports. Protect steel members and packaged materials from corrosion and deterioration.

2. Provide secure storage area for finish hardware items, secured by locks and accessible only to finish hardware installer, Design Professional's Spec Term and Contractor's Spec Term.
3. Store finish hardware in manufacturers' original packages.

C. Acceptance at Site:
1. All boxes, crates and packages shall be inspected by Contractor's Spec Term upon delivery to the Site. Contractor's Spec Term shall notify Owner's Spec Term, in writing, if any loss or damage exists to equipment or components. Items that arrive in a damaged condition shall be removed from the Site and not offered again for acceptance. Replace loss and repair damage to new condition in accordance with manufacturer's instructions.

PART 2 PRODUCTS

2.01 SYSTEM PERFORMANCE

A. Description:
1. Where the finish, shape, size, fire-resistance-rating, frequency of use, or function of a member receiving finish hardware is such as to prevent, or make unsuitable, the types of finish hardware specified, furnish similar types having as nearly as practicable the same operation but of type or kind more appropriate to the design intension and requirements of governing authorities having jurisdiction at the Site. Clearly identify and highlight to the Design Professional's Spec Term and Owner's Spec Term all such required modifications on Shop Drawings submitted for approval.
2. If finish hardware for any location is not specified, provide finish hardware equal in design and quality to adjacent finish hardware specified for comparable openings at no additional cost to Owner's Spec Term.
3. Furnish finish hardware items of proper design for use on doors and frames of the thickness, profile, swing, security and similar requirements, as necessary for proper installation and function.
4. Unless otherwise specified, comply with DHI, Recommended Locations for Architectural Hardware for Standard Steel Doors and Frames and Recommended Locations for Builders' Hardware for Custom Steel Doors and Frames.

2.02 DETAILS OF CONSTRUCTION

A. General:
1. Hand of Door: The Drawings show the swing or hand of each door leaf (left, right, reverse bevel, etc.). Furnish each item of finish hardware for proper installation and operation of the door swing as shown.
2. Manufacturer's Name Plate: Do not use manufacturer's products which have manufacturer's name or trade name displayed in a visible location (omit removable nameplates), except in conjunction with labels required by governing authorities having jurisdiction at the Site.
3. Base Metals: Produce finish hardware units of the basic metal and forming method specified, using the manufacturer's standard metal alloy, composition, temper and hardness. Do not substitute materials or forming methods for those specified.

4. Fasteners: Manufacture finish hardware to conform to published templates, generally prepared for machine screw installation. Do not provide finish hardware, which has been prepared for self-tapping sheet metal screws, except as specifically indicated.
5. Furnish screws for installation, with each finish hardware item. Provide Phillips flat-head screws except as otherwise specified. Finish exposed (exposed under any condition) screws to match the hardware finish or, if exposed in surfaces on other Work, to match the finish of such other Work as closely as possible, including "prepared for paint" in surfaces to receive painted finish.
6. Provide fasteners which are compatible with both the unit fastened and the substrate, and which will not cause corrosion or deterioration of finish hardware, base material or fastener.
7. Provide concealed fasteners for finish hardware units, which are not exposed when the door is closed, except to the extent no standard manufacturer units of the type specified are available with concealed fasteners. Do not use through bolts for installation where the bolt head or the nut on the opposite face is exposed in other Work under any condition, except where it is not possible to adequately reinforce the Work and use machine screws or concealed fasteners of another standard type to satisfactorily avoid the use of through bolts.
8. Tools for Maintenance: Furnish two complete sets of specialized tools as required for Owner's Spec Term's continued adjustment, maintenance, removal and replacement of finish hardware.

B. Mortise Hinges:
1. Templates and Screws: Provide only template-produced units.
2. Base Metal: Except as otherwise specified, fabricate hinges from stainless steel and finish to match the latch and lock set.
3. Number of Hinges: Provide two hinges on each door leaf of less than 60-inches in height; provide one additional hinge for next 30-inches of door height or fraction thereof; provide two additional hinges for each 30-inches, or fraction thereof, for doors above 90-inches tall.
4. Hinge Size: Except as otherwise specified or as required to comply with UL and NFPA, provide hinges of the following sizes:
    a. Interior Doors:
        1) Average Use, Maximum 36-Inches Wide: 4-1/2-inch standard weight (0.134-inches).
        2) Heavy Use, Maximum 36-Inches Wide: 4-1/2-inch heavyweight (0.180-inches).
    b. Exterior Doors, Maximum 36-Inches Wide: 4-1/2-inch heavyweight (0.180-inch).
    c. Wide Exterior and Interior Doors:
        1) Maximum 48-inches wide: 5-inch heavyweight (0.190-inch).
        2) Over 48-inches wide: 6-inch heavy weight (0.203-inch).
5. Types of Hinges: Provide full-mortise type, ball-bearing hinges, swaged for mortise applications, inner leaf beveled, square cornered, unless manufacturer's recommendations indicate that half-mortise, half-surface, full-surface or other type should be used for the frame and door type or condition.
6. Hinge Pins: Except as otherwise specified, provide hinge pins as follows:

a. Pins: Stainless steel.
b. Exterior Doors: Non-removable pins. Provide setscrew in hinge barrel that, when tightened into a groove in hinge pin, prevents removal of pin while door is closed.
c. Tips: Slope ends of hinge barrel.

7. Conform to BHMA A156.7.
8. Comply with UL, List of Inspected Fire Protection Equipment and Materials and NFPA 80 requirements.
9. Products and Manufacturer: Provide one of the following:
   a. FBB 199 and FBB 191 by Stanley Commercial Hardware, Division of The Stanley Works.
   b. T4B3386 and TB3313 by McKinney Products Company, Division of ESSEX Industries, Incorporated.
   c. Or approved equal.

C. Cylinders and Keying System:
1. Standard System: Except as otherwise specified, provide new master key system for the Project.
2. Multiple-Building System: Except as otherwise specified, provide new grandmaster key system for Project.
3. Existing System: Grandmaster key or great-grandmaster keys the locks to Owner's Spec Term's existing system, with a new master key for the Project.
4. Review the keying system with Owner's Spec Term's and provide the type required (master, grandmaster or great grandmaster), either new or integrated with Owner's Spec Term's existing system.
5. Furnish all locks with manufacturer's cylinders for interchangeable-core pin tumbler inserts. Furnish only temporary inserts for the construction period, and remove these before Substantial Completion. Construction control keys and cores shall not be part of Owner's Spec Term's permanent keying system. Permanent cores and keys shall be furnished to Owner's Spec Term prior to Substantial Completion.
6. Comply with the Owner's Spec Term's instructions for master keying and, except as otherwise specified, provide individual change key for each lock which is not designated to be keyed alike with a group of related locks.
7. Permanent keys and cores shall be stamped with the applicable key mark for identification. These visual key control marks or codes shall not include the actual key cuts. Permanent keys shall also be stamped "DO NOT DUPLICATE".
8. Cylinder Material: Brass, bronze or Series 300 stainless steels.
9. Cylinder Features: Seven-pin, high-security, removable core.
10. Key Material: Nickel silver.
11. Key Quantity: Furnish three keys for each lock and five keys for each master and grandmaster system. Provide one extra key blank for each lock.
12. Provide a key control system including envelopes, labels, tags with self-locking key clips, receipt forms, three-way visible card index, temporary markers, permanent markers and standard metal cabinet, all as recommended by system manufacturer, with capacity for 150 percent of the number of locks required for the Project. Provide a hinged-panel type cabinet, for wall mounting.

D. Overhead, Surface-Mounted, Door Closers:
   1. Provide all doors, unless specially shown or specified as being provided with floor-mounted or concealed overhead closers, with surface-mounted overhead door closers. Provide both active and inactive door leafs with closers.
   2. Size of Units: Except as otherwise specified, comply with the manufacturer's recommendations for size of door control unit, depending upon size of door, exposure to weather, and anticipated frequency of use.
   3. Where parallel arms are specified, and for closers on exterior doors, provide closer unit one size larger than recommended for use with standard arms.
   4. Use parallel arm arrangement for doors that would otherwise have the door closer appearing in finished corridors or entries.
   5. Comply with UL, Building Materials Directory, and List of Inspected Fire Protection Equipment and Materials, and NFPA 800. Modify closers specified as required.
   6. Provide hold open feature for all non-fire-resistant-rated doors, unless otherwise specified.
   7. Provide corner bracket mounting on exterior doors. Select all arms to clear weather-stripping, and overhead door holders.
   8. Provide long arm to allow door to swing 180 degrees where long arm will eliminate floor-mounted stops.
   9. Provide closers with spring power adjustment feature capable of increasing spring power 15 percent minimum in all closer sizes.
   10. Provide individual regulating valves for closing and latching speeds, and separate adjustable back check valve.
   11. Provide delayed closing action feature on all door closers. Position valve at top of closure.
   12. Provide the following materials and features:
      a. Full Metal Cover: Aluminum.
      b. Case: Cast-iron.
      c. Arms: Plated to match full metal covers.
      d. Other Parts: Steel.
      e. Extreme temperature fluid.
      f. Security torx machine screws.
      g. Ten-year warranty.
      h. Provide manufacturer's optional corrosion protection.
   13. Finishes: US 26D satin chrome. Color coordinate all arms and other accessories.
   14. Highly Corrosive Atmospheres: Provide all closers with specified manufacturer’s optional corrosion protection.
   15. BHMA A156.4, C02011, in compliance with PT 1 and PT 4.
   16. Products and Manufacturer: Provide one of the following:
      a. DC2000DA M71, M73, M74, M75, M87 by Corbin Russ win, Incorporated, Division of Yale Security Group.
      b. or approved equal.

E. Dust-Proof Strikes:
   1. Provide brass dust-proof strikes, which incorporate a slotted plunger raised to flush position by spring tension for all flush bolts.
   2. Provide 5/8-inch inside diameter dust-proof strikes; threshold mounted and surface mounted.
   3. Finish: US 26D satin chrome.
   4. BHMA A156.16, L14011-L14012.
   5. Products and Manufacturers: Provide one of the following:
      a. DP-1 and DP-2 by Glynn-Johnson Part of Worldwide Ingersoll-Rand.
      b. or approved equal.

F. Door Pulls, Push and Protection Armor:
   1. Door Pulls: Provide heavy-duty surface-mounted door pulls with pull plates where specified in List of Finish Hardware Items at end of Part 3.
      a. Door pulls shall be stainless steel US 32D and have 1-inch diameter 12-inch long handles which project 2-1/2-inches from pull plate surface.
      b. Pull plates shall be 8-inches by 16-inches, stain less steel US 32D; 0.050-inches thick.
      c. Provide all non-removable fasteners.
      d. Pulls shall be fastened to plates at factory.
      e. BHMA A156.6, J405; B3E.
      f. Products and Manufacturers: Provide one of the following:
         1) 40 Series Pull Plates and Handles by Hager Hinger Company.
         2) or approved equal.
   2. Push Plates:
      a. Provide 0.125-inch thick stainless steel plate with No. 4 finish.
      b. Size: 8-inches by 16-inches with beveled edges.
      c. BHMA A156.6, J304; B3E.
      d. Products and Manufacturers: Provide one of the following:
         1) 80S Beveled by Hager Hinger Company.
         2) or approved equal.
   3. Protection Armor:
      a. Provide one armor plate per leaf of each door scheduled to receive armor-plate protection.
      b. Provide 16-gauge stainless steel with No. 4 finish 2 foot-0 inches high by 2-inches less in width than width of door.
      c. BHMA A156.6, J101; B3E.
      d. Products and Manufacturers: Provide one of the following:
         1) 193S Beveled Stainless Steel Armor Plate by Hager Hinge Company.
         2) or approved equal.

G. Stripping and Seals:
   1. Provide perimeter weather stripping at all exterior doors. Provide stripping and seals for interior doors where scheduled in List of Finish Hardware Items at end of Part 3.
   2. Continuity of Stripping: Except as otherwise specified, stripping at each opening shall be continuous and without unnecessary interruptions at door corners and hardware.
   3. Replaceable Seal Strips: Resilient or flexible seal strip of every unit shall be easily replaceable and readily available from stocks maintained by the manufacturer.
   4. Provide bumper-type weather-stripping at jambs and head, including a resilient insert and metal retainer strip, surface-a pplied, of the following metal, finish and resilient bumper material:
      a. Housing: Extruded aluminum with dark bronze anodized finish; 0.062-inch minimum thickness of main walls and flanges.
      b. Dimensions: 1-3/8-inches by 7/8-inches, stop-mounted.
      c. Seals: Closed-cell extruded silicone.
      d. BHMA A156.22, R3E264.
      e. Products and Manufacturers: Provide one of the following:
         1) No. 350DSPK and 2891 DPK (for parallel arms) by Pemko Manufacturing Company.
         2) or approved equal.
   5. Provide heavy-duty automatic drop-seal sound-stripping door-bot tom unit of manufacturer's standard design, with operating seal bar of the following material, retained in an extruded metal bar and capable of operating to close a 3/4-inch gap (from door bottom to floor or threshold). House mechanism and operating bar in the following metal housing, for mounting in doors as follows:
      a. Housing: Extruded aluminum, 0.062-inch thick, with mill aluminum finish.
      b. Seal: Closed-cell extruded silicone.
      c. Mounting: Full-mortise.
      d. BHMA A156.22, R3E344.
      e. Products and Manufacturers: Provide one of the following:
         1) No. 434APKL by Pemko Manufacturing Company.
         2) or approved equal.

H. Thresholds:
   1. All exterior and interior doors shall be provided with thresholds.
   2. Metal: Mill finish extruded bronze.
   3. Surface Pattern: Fluted tread, manufacturer's standard.
   4. Provide countersunk stainless-steel screws and expansion shields.
   5. Width: Five-inches wide and of length sufficient to span full width of rough openings, coped and scribed neatly at and around doorframes.
   6. Construction:
      a. Single-piece, complying with manufacturer's recommendations.
   7. Profile: Provide manufacturer's unit, which conforms to the minimum size and profile requirements specified.

a. Floor Drop: Except where no change in floor elevation is shown from one side of threshold to the other, provide profile that accommodates 1/2-inch drop in floor elevation, unless another dimension is shown.
b. For doors equipped with panic hardware, including floor bolts, provide profile with stop bar of proper size and shape to function as the strike plate for the floor bolts.

8. Thickness: 1/2-inch, minimum.
9. BHMA A156.21, J12100.
10. Products and Manufacturers: Provide one of the following:
    a. 171B by Pemko Manufacturing Company.
    b. or approved equal.

I. Silencers:

J. Provide silencers for all door frames.
1. Provide pneumatic design that, once installed, forms an air pocket to reduce noise.
2. Provide minimum of three per strike side of doorjambs.
3. BHMA A156.16, BHMA 6.5, L03011.
4. Products and Manufacturers: Provide one of the following:
    a. GJ 64 by Glynn-Johnson Part of Worldwide Ingersoll-Rand.
    b. or approved equal.

K. Sealants: Provide elastomeric sealant complying with FS TT-S-00227, Type 2 (non-sag) Class A for use with thresholds.

2.03 HARDWARE FINISHES

A. Provide matching finishes for finish hardware units at each door or opening, to the greatest extent possible in compliance with BHMA A156.18.

B. Reduce differences in color and textures as much as commercially possible where the base metal or metal forming process is different for individual units of finish hardware exposed at the same door or opening. In general, match all items to the manufacturer's standard finish for the latch and lock set for color and texture.

PART 3 EXECUTION

3.01 INSPECTION

A. Examine the substrate to receive finish hardware, and the conditions under which the Work will be performed, and notify the Owner's Spec Term, in writing, of unsatisfactory conditions. Do not proceed with the finish hardware Work until unsatisfactory conditions have been corrected in a manner acceptable to the Owner's Spec Term.

3.02 PREPARATION

A. Templates: Furnish finish hardware templates to each fabricator of doors, frames and other Work to be factory-prepared for the installation of finish hardware. Check the Shop

Drawings of such other Work, to confirm that adequate provisions are made for the proper installation of the finish hardware.

B. Prepare Work to receive finish hardware Work in compliance with ANSI/DHI A115.1.

3.03 INSTALLATION

A. Installer shall check and approve the installation before operation. Installer shall assure that the system operates to the Owner's Spec Term's satisfaction.

B. Mount finish hardware units at heights recommended in, Door and Hardware Institute, “Recommended Locations for Architectural Hardware for Standard Steel Doors and Frames” and “Recommended Locations for Builders’ Hardware for Custom Steel Doors and Frames", except as otherwise specified or required to comply with governing authorities having jurisdiction at the Site, NAAMM HMMA 830 and ADAAG requirements.

C. Install each finish hardware item in compliance with the manufacturer's instructions and recommendations and approved Shop Drawings. Wherever cutting and fitting is required to install finish hardware onto or into surfaces that are later to be painted or finished in another way, install each item completely, then remove, and store in a secure place during the finish application. After completion of the finishes, re-install each item. Do not install surface-mounted items until finishes have been completed on the substrate.

D. Set units level, plumb and true to line and location. Adjust and reinforce the attachment substrate as necessary for proper installation and operation.

E. Drill and countersink units that are not factory-prepared for anchorage fasteners. Space fasteners and anchors in accordance with industry standards.

F. Cut and fit threshold and floor covers to profile of doorframes, with mitered corners and hair-line joints. Join units with concealed welds or concealed mechanical joints. Cut smooth openings for spindles, bolts and similar items, if any.

G. Screw thresholds to substrate with No. 10 or larger screws, of the proper type for permanent anchorage and of bronze or stainless steel that will not corrode in contact with the threshold metal.

H. Set thresholds in a bead of elastomeric sealant to completely fill concealed voids and exclude moisture from every source. Do not plug drainage holes or block weeps. Remove excess sealant before sealant cures to a firm set.

I. Adjust and check each operating item of finish hardware and each door, to ensure proper operation or function of every unit. Lubricate moving parts with the type lubrication recommended by manufacturer (graphite-type if no other recommended). Replace units that cannot be adjusted and lubricated to operate freely and smoothly as intended for the application.

J. Final Adjustment: Where finish hardware installation is made more than one month prior to Substantial Completion, return to the Work during the week prior to acceptance or occupancy, and make a final check and adjustment of all finish hardware items in each space and area. Clean and re-lubricate operating items as necessary to restore proper

function and finish of finish hardware and doors. Adjust door control devices to compensate for final operating of heating and ventilating equipment.

K. Provide manufacturer’s authorized representative to instruct and train Owner's Spec Term's personnel in proper adjustment and maintenance of finish hardware during the final adjustment of finish hardware.

L. Finish hardware, which is blemished or defective, will be rejected even though it was set in place before defects were discovered. Remove and replace with new finish hardware. Repair all resultant damage to other Work.

M. Continued Maintenance Service: Approximately six months after the acceptance of finish hardware in each area, the installer, accompanied by the representative of the latch and lock manufacturer, shall return to the Project and re-adjust every item of hardware to restore proper function of doors and finish hardware. Consult with and instruct Owner's Spec Term's personnel in recommended additions to the maintenance procedures. Clean and lubricate operational items wherever required. Replace finish hardware items that have deteriorated or failed due to faulty design, materials or installation of finish hardware units. Prepare a written report of current and predictable problems (of substantial nature) in the performance or the finish hardware.

3.04 FIELD QUALITY CONTROL

A. Provide a written field report, prepared by installer’s architectural hardware consultant, identifying actual condition, location, manufacturer, and product designation for each item of finish hardware actually present on each door at the Site, including whether finish hardware is adjusted and operating properly, compared with each item referenced to approved Shop Drawings and Contract requirements.

B. Installer’s hardware consultant shall provide opinions to, and assist Design Professional's Spec Term in determining, acceptability of installation as Work proceeds. All comments and discussions, conversations and meetings with Design Professional's Spec Term shall be included in written field report for submission to Design Professional's Spec Term for review and approval at completion of finish hardware installation.

C. As part of written field report to be submitted to Design Professional's Spec Term for approval, recommend remedial actions for Work not in compliance with these Specifications. No payment for Work shall be made until remedial recommendations and actions have been approved by Design Professional's Spec Term and incorporated into the Work.

3.05 LIST OF FINISH HARDWARE ITEMS

A. Scheduled items for each door are generic and rely on information specified above. The listing of hardware functions and types provided are only a general guideline for the final Finish Hardware Schedule. Contractor's Spec Term shall submit a Finish Hardware Schedule acceptable to all governing authorities having jurisdiction at the Site. If door is missing provide hardware set similar to other doors on project.

B. Hardware Set Schedule: Provide the following finish hardware items:

1. Doors SP-D201, - Single Exterior Egress Door

a. Mortise Hinges
b. Entry Latchset
c. Door Closer/Holder
d. Protection Armor
e. Stripping and Seals
f. Threshold
g. Door Bottom Seal

END OF SECTION

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SECTION 08 81 00

GLAZING

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes (for the glazing in the new exterior door):
   1. Glass products.
   2. Insulating glass.
   3. Glazing tapes.

1.02 COORDINATION

A. Coordinate glazing channel dimensions to provide necessary bite on glass, minimum edge and face clearances, and adequate sealant thicknesses, with reasonable tolerances.

1.03 ACTION SUBMITTALS

A. Product Data: For each type of product.

1.04 INFORMATIONAL SUBMITTALS

A. Product Certificates: For glass.

B. Product test reports.

C. Preconstruction adhesion and compatibility test report.

D. Sample warranties.

1.05 QUALITY ASSURANCE

A. Sealant Testing Agency Qualifications: An independent testing agency qualified according to ASTM C1021 to conduct the testing indicated.

1.06 WARRANTY

A. Manufacturer's Special Warranty for Coated-Glass Products: Manufacturer agrees to replace coated-glass units that deteriorate within specified warranty period. Deterioration of coated glass is defined as defects developed from normal use that are not attributed to glass breakage or to maintaining and cleaning coated glass contrary to manufacturer's written instructions. Defects include peeling, cracking, and other indications of deterioration in coating.
   1. Warranty Period: 10 years from date of Substantial Completion.

B. Manufacturer's Special Warranty for Insulating Glass: Manufacturer agrees to replace insulating-glass units that deteriorate within specified warranty period. Deterioration of insulating glass is defined as failure of hermetic seal under normal use that is not attributed to glass breakage or to maintaining and cleaning insulating glass contrary to manufacturer's written instructions. Evidence of failure is obstruction of vision by dust, moisture, or film on interior surfaces of glass.
   1. Warranty Period: 10 years from date of Substantial Completion.

PART 2 PRODUCTS

2.01 PERFORMANCE REQUIREMENTS

A. Safety Glazing: Where safety glazing is indicated, provide glazing that complies with 16 CFR 1201, Category II.

B. Thermal and Optical Performance Properties: Provide glass with performance properties specified, as indicated in manufacturer's published test data, based on procedures indicated below:
   1. U-Factors: Center-of-glazing values, in accordance with NFRC 100 and based on LBL's WINDOW 7 computer program, expressed as Btu/sq. ft. x h x deg F.
   2. SHGC and Visible Transmittance: Center-of-glazing values, in accordance with NFRC 200 and based on LBL's WINDOW 7 computer program.
   3. Visible Reflectance: Center-of-glazing values, in accordance with NFRC 300.

2.02 GLASS PRODUCTS, GENERAL

A. Glazing Publications: Comply with published recommendations of glass product manufacturers and organizations below unless more stringent requirements are indicated. See these publications for glazing terms not otherwise defined in this Section or in referenced standards.
   1. AAMA Publications: AAMA GDSG-1, “Glass Design for Sloped Glazing,” and AAMA TIR A7, “Sloped Glazing Guidelines.”
   2. IGMA Publication for Insulating Glass: SIGMA TM-3000, “North American Glazing Guidelines for Sealed Insulating Glass Units for Commercial and Residential Use.”

B. Safety Glazing Labeling: Where safety glazing is indicated, permanently mark glazing with certification label of the SGCC or another certification agency acceptable to authorities having jurisdiction or manufacturer. Label shall indicate manufacturer's name, type of glass, thickness, and safety glazing standard with which glass complies.

C. Insulating-Glass Certification Program: Permanently marked either on spacers or on at least one component lite of units with appropriate certification label of the IGCC.

D. Thickness: Where glass thickness is indicated, it is a minimum. Provide glass that complies with performance requirements and is not less than thickness indicated.

E. Strength: Where annealed float glass is indicated, provide annealed float glass, heat-strengthened float glass, or fully tempered float glass as needed to comply with “Performance Requirements” Article. Where heat-strengthened float glass is indicated, provide heat-strengthened float glass or fully tempered float glass as needed to comply with “Performance Requirements” Article. Where fully tempered float glass is indicated, provide fully tempered float glass.

2.03 GLASS PRODUCTS

A. Fully Tempered Float Glass: ASTM C1048, Kind FT (fully tempered), Condition A (uncoated) unless otherwise indicated, Type I, Class 1 (clear) or Class 2 (tinted) as indicated, Quality-Q3.

2.04 INSULATING GLASS

A. Insulating-Glass Units: Low-E factory-assembled units consisting of sealed lites of glass separated by a dehydrated interspace, and certified through the Insulating Glass Certification Council (IGCC) qualified in accordance with ASTM E2190 and E-2188.
   1. Sealing System: Dual seal, with manufacturer's standard primary and secondary sealants.
   2. Perimeter Spacer: Stainless steel.
   3. Desiccant: Molecular sieve or silica gel, or a blend of both.
   4. Glass shall be made from tempered glass, or heat-strengthened glass where recommended by manufacturer for application indicated. The unit shall consist of a tinted 1/4" thick exterior light, 1/2" air space and 1/4" thick clear interior light. Sealing system shall consist of metal spacer with bent or soldered corners, butyl primary and silicone secondary seal. Desiccant shall be manufacturer's standard. Exterior pane shall be tinted and color shall be selected by the Owner from manufacturer's full range of colors. Exterior glass shall be insulated.

2.05 GLAZING TAPES

A. Back-Bedding Mastic Glazing Tapes: Preformed, butyl-based, 100 percent solids elastomeric tape; nonstaining and nonmigrating in contact with nonporous surfaces; with or without spacer rod as recommended in writing by tape and glass manufacturers for application indicated; and complying with ASTM C1281 and AAMA 800 for products indicated below:
   1. AAMA 804.3 tape, where indicated.
   2. AAMA 806.3 tape, for glazing applications in which tape is subject to continuous pressure.
   3. AAMA 807.3 tape, for glazing applications in which tape is not subject to continuous pressure.

B. Expanded Cellular Glazing Tapes: Closed-cell, PVC foam tapes; factory coated with adhesive on both surfaces; and complying with AAMA 800 for the following types:
   1. AAMA 810.1, Type 1, for glazing applications in which tape acts as primary sealant.
   2. AAMA 810.1, Type 2, for glazing applications in which tape is used in combination with a full bead of liquid sealant.

PART 3 EXECUTION

3.01 GLAZING, GENERAL

A. Comply with combined written instructions of manufacturers of glass, sealants, gaskets, and other glazing materials, unless more stringent requirements are indicated, including those in referenced glazing publications.

B. Protect glass edges from damage during handling and installation. Remove damaged glass from Project site and legally dispose of off Project site. Damaged glass includes glass with edge damage or other imperfections that, when installed, could weaken glass, impair performance, or impair appearance.

C. Apply primers to joint surfaces where required for adhesion of sealants, as determined by preconstruction testing.

D. Install setting blocks in sill rabbets, sized and located to comply with referenced glazing publications, unless otherwise required by glass manufacturer. Set blocks in thin course of compatible sealant suitable for heel bead.

E. Do not exceed edge pressures stipulated by glass manufacturers for installing glass lites.

F. Provide spacers for glass lites where length plus width is larger than 50 inches.

G. Provide edge blocking where indicated or needed to prevent glass lites from moving sideways in glazing channel, as recommended in writing by glass manufacturer and in accordance with requirements in referenced glazing publications.

3.02 TAPE GLAZING

A. Position tapes on fixed stops so that, when compressed by glass, their exposed edges are flush with or protrude slightly above sightline of stops.

B. Install tapes continuously, but not necessarily in one continuous length. Do not stretch tapes to make them fit opening.

C. Cover vertical framing joints by applying tapes to heads and sills first, then to jambs. Cover horizontal framing joints by applying tapes to jambs, then to heads and sills.

D. Place joints in tapes at corners of opening with adjoining lengths butted together, not lapped. Seal joints in tapes with compatible sealant approved by tape manufacturer.

E. Apply heel bead of elastomeric sealant.

F. Center glass lites in openings on setting blocks and press firmly against tape by inserting dense compression gaskets formed and installed to lock in place against faces of removable stops. Start gasket applications at corners and work toward centers of openings.

G. Apply cap bead of elastomeric sealant over exposed edge of tape.

3.03 GASKET GLAZING (DRY)

A. Cut compression gaskets to lengths recommended by gasket manufacturer to fit openings exactly, with allowance for stretch during installation.

B. Insert soft compression gasket between glass and frame or fixed stop so it is securely in place with joints miter cut and bonded together at corners.

C. Installation with Drive-in Wedge Gaskets: Center glass lites in openings on setting blocks and press firmly against soft compression gasket by inserting dense compression gaskets formed and installed to lock in place against faces of removable stops. Start gasket applications at corners and work toward centers of openings. Compress gaskets to produce a weathertight seal without developing bending stresses in glass. Seal gasket joints with sealant recommended in writing by gasket manufacturer.

D. Installation with Pressure-Glazing Stops: Center glass lites in openings on setting blocks and press firmly against soft compression gasket. Install dense compression gaskets and pressure-glazing stops, applying pressure uniformly to compression gaskets. Compress gaskets to produce a weathertight seal without developing bending stresses in glass. Seal gasket joints with sealant recommended in writing by gasket manufacturer.

E. Install gaskets so they protrude past face of glazing stops.

3.04 CLEANING AND PROTECTION

A. Immediately after installation, remove nonpermanent labels and clean surfaces.

B. Protect glass from contact with contaminating substances resulting from construction operations. Examine glass surfaces adjacent to or below exterior concrete and other masonry surfaces at frequent intervals during construction, but not less than once a month, for buildup of dirt, scum, alkaline deposits, or stains.
   1. If, despite such protection, contaminating substances do contact with glass, remove substances immediately as recommended in writing by glass manufacturer. Remove and replace glass that cannot be cleaned without damage to coatings.

C. Remove and replace glass that is damaged during construction period.

3.05 INSULATING GLASS SCHEDULE

A. Clear Insulating Glass Type:
   1. Overall Unit Thickness: 1 inch.
   2. Minimum Thickness of Each Glass Lite: 6 mm.
   3. Outdoor Lite: Fully tempered float glass.
   4. Interspace Content: Argon.
   5. Indoor Lite: Fully tempered float glass.
   6. Safety glazing required.

END OF SECTION

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SECTION 09 90 00

GENERAL COATING SPECIFICATION

PART 1 GENERAL

1.01 DESCRIPTION

A. Scope:
   1. This Section specifies coating system materials, surface preparations, application, and quality control (QC) requirements.
   2. This Section includes:
      a. All substrates exposed to non-corrosive or moderately corrosive environment.
      b. Atmospheric, weathering exposure, non-corrosive building exposure conditions and piping, equipment, and structures not exposed to immersion services or corrosive headspace (gaseous) exposures, and
      c. internal building surfaces substrates for areas occupied by personnel.
   3. The Contractor is solely responsible for all aspects of QC inspections for the work covered by this Section. The QC inspection personnel and coating manufacturer technical representative (CTR) are provided by the General Contractor at no additional cost to the Owner. Inspections, testing, or other forms of quality checks may be provided by the Construction Manager for quality assurance (QA) checks but in no way relieve the Contractor of sole responsibility for quality and performance of the installed coating system.

1.02 RELATED SECTIONS

A. This section contains specific references to the following related sections. Additional related sections may apply that are not specifically listed below.
   1. Section 01 11 80 Environmental Conditions
   2. Section 01 33 00 Submittal Procedures
   3. Section 01 45 00 Contractor Quality Control
   4. Section 01 45 23 Testing and Inspection Services
   5. Section 01 61 45 Area Exposure Designations
   6. Section 01 66 00 Product Storage and Handling
   7. Section 01 99 90 Reference Forms

1.03 DEFINITIONS

A. Specific coating terminology used in this Section is in accordance with definitions contained in ASTM D16, ASTM D3960, and the following definitions.
   1. Abrasive: Material used for blast cleaning, such as sand, grit or shot.
   2. Abrasive Blast Cleaning: Cleaning/surface preparation by abrasive propelled at high speed by compressed air.
   3. AMPP: Association for Materials Protection and Performance (Merger of National Association of Corrosion Engineers and Society for Protective Coatings).
   4. Anchor Pattern: Profile or texture of prepared surface(s).
   5. ANSI: American National Standards Institute.

6. Bug Holes: Cavities or air voids resulting from entrapment of air bubbles in the surface of formed concrete during placement and compaction.
7. Coating Thickness: The total dry film thickness of primer, intermediate, and/or finish coats.
8. Coating System Applicator (CSA): A generic reference to the specialty subcontractor or subcontractors retained by the Contractor to install the coating systems specified in this Section.
9. Coating System Manufacturer (CSM): Refers to the acceptable coating system manufacturer, abbreviated as the CSM.
10. Coating System Manufacturer's Technical Representative(s) (CTR): Refers to the independent technical representative(s) of the acceptable Coating System Manufacturer and is abbreviated as CTR. This refers to a CSM technical representative and not a sales or marketing representative. The cost of this independent technical representative is the responsibility of the General Contractor.
11. Dew point: Temperature of a given air/water vapor mixture at which condensation starts.
12. Dry Film Thickness (DFT): Depth of cured film, usually expressed in mils (0.001 inch). DFT is the thickness of a coating as measured above the substrate.
13. Dry Spray: Dry, flat, probably textured coating surface when spray gun held too far from substrate.
14. Drying Time or curing time: Time interval between application and curing of material before exposure to service conditions.
15. Dry to Recoat: Time interval between application of material and ability to receive next coat.
16. Dry to Touch: Time interval between application of material and ability to touch lightly without damage.
17. Feather Edging: Reducing the thickness of the edge of paint.
18. Feathering: Operation of tapering off the edge of a point with a comparatively dry brush.
19. Field Coat: The application or the completion of application of the coating system after installation of the surface receiving coating at the site of the work.
20. Fish Eyes: Separation or pulling apart of wet film of coating to expose underlying film or substrate.
21. Flash Report: A report by email or text to the Construction Manager and Engineer identifying issues requiring immediate attention and approval.
22. Hold Point: A defined point, specified in this Section, at which work shall be halted for a quality inspection.
23. Holiday: A discontinuity, skip, or void in coating or coating system film that exposes the substrate.
24. Honeycomb: Segregated condition of hardened concrete due to non-consolidation.
25. ICRI: International Concrete Repair Institute.
26. Incompatibility: Inability of a coating to perform well over another coating because of lack of cure of prior coating, poor bonding, or lifting of old coating; inability of a coating to perform well on a substrate.

27. Laitance: A layer of weak, non-durable concrete containing cement fines that are brought to the surface through bleed water because of concrete finishing and/or over-finishing.
28. LEED: Leadership in Energy and Environmental Design certification program by the US Green Building Council.
29. Mil: 0.001 inch, one thousandth of an inch.
30. Mudcracking: Deep irregular cracks in coating that resemble dried mud caused by non-flexible coatings applied too thickly or built-up in corners.
31. NACE: National Association of Corrosion Engineers to be renamed Association of Materials Performance and Protection or AMPP.
32. NAPF: National Association of Pipe Fabricators.
33. Certified Coatings Inspector: Must be AMPP Certified to Level 3 and have at least 10 years' experience in wastewater coatings inspection.
34. Overspray: Coating spray, particularly such coating that failed to strike the intended surface and ended up on surfaces not to be coated.
35. Pinhole: A small diameter discontinuity in a coating or coating system film that is typically created by outgassing of air from a void in a concrete substrate resulting in exposure of the substrate or a void between coats.
36. Pot Life: Time interval after mixing of components during which the coating can be satisfactorily applied.
37. QA: Quality Assurance
38. QC: Quality Control
39. QCP: Quality Control Person representing the Contractor and responsible for QC Testing, Inspection and associated documentation.
40. Quality Control Testing and Inspection Plan (QCTIP).
41. Repair Mortars: Cementitious, polymer modified cementitious, or polymer-based mortars used to restore concrete or masonry substrates to overall continuous, coatable surfaces by filling voids and excess substrate profile that cannot be hidden by the DFT of the coating system.
42. Resurfacer/Resurfacing Material: A layer of cementitious and/or resin-base material used to fill or otherwise restore surface continuity to worn or damaged concrete surfaces at typically shallow depths up to 1/4 inch thick.
43. Shelf Life: Maximum storage time for which a material may be stored without losing its usefulness.
44. Shop Coat: One or more coats applied in a shop or plant prior to shipment to the site of the work, where the field or finishing coat is applied.
45. Spreading Rate: Area covered by a unit volume of paint at a specific thickness.
46. SSPC: The Society for Protective Coatings soon to become part of AMPP.
47. Stripe Coat: A separate coat of paint applied to all weld seems, pits, nuts/bolts/washers and edges by brush. This coat shall be applied prior to full coat application.
48. Saturated Surface Dry (SSD): Refers to concrete surface condition where the surface is saturated (damp) without the presence of standing water.
49. Tie Coat: An intermediate coat used to bond different types of paint coats. Coatings used to improve the adhesion of a succeeding coat.

50. Touch-Up Painting: The application of paint on areas of painted surfaces to repair marks, scratches, and areas where the coating has deteriorated to restore the coating film to an unbroken condition.
51. TPC: Technical Practice Committee.
52. Volatile Organic Compound (VOC) Content: The portion of the coating that is a compound of carbon, is photochemically reactive, and evaporates during drying or curing, expressed in grams per liter (g/l) or pounds per gallon (lb/gal).
53. Immersion: Refers to a service condition in which the substrate is below the waterline or submerged in a liquid such as water or wastewater at least intermittently if not constantly.
54. Weld Spatter: Beads of metal scattered near seam during welding.
55. Wet Film Thickness (WFT): The primer or coating film's thickness immediately following application. Wet film thickness is measured in mils or thousandths of an inch (0.001 inch) and is abbreviated WFT.

1.04 REFERENCES

A. This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.

B. Unless otherwise specified, references to documents mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid (or on the effective date of the Agreement if there were no Bids). If referenced documents have been discontinued by the issuing organization, references to those documents mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, use the last version of the document before it was discontinued.

Reference	Title
ANSI/ASC 29.4 Exhaust Systems	Abrasive Blasting Operations – Ventilation and Safe Practice
ANSI/NSF 61/600	Drinking Water System Components Health Effect
ANSI B74.18	Grading of Certain Abrasive Grain on Coated Abrasive Material
ASTM C1583	Standard Test Method for Tensile Strength of Concrete Surfaces and the Bond Strength or Tensile Strength of Concrete Repair and Overlay Materials by Direct Tension (Pull-Off Method)
ASTM D16	Standard Terminology for Paint, Related Coatings, Materials, and Applications
ASTM D2200 (SSPC-VIS1)	Pictorial Surface Preparation Standards for Painting Steel Surfaces
ASTM D3359	Standard Test Methods for Rating Adhesion by Tape Test
ASTM D3960	Standard Practice for Determining Volatile Organic Compound (VOC) Content of Paints and Related Coatings
ASTM D4262	Standard Test Method for pH of Chemically Cleaned or Etched Concrete Surfaces
ASTM D4263	Standard Test Method for Indicating Moisture in Concrete by the Plastic Sheet Method
ASTM D4285	Standard Test Method for Indicating Oil or Water in Compressed Air
ASTM D4414	Standard Practice for Measurement of Wet Film Thickness by Notch Gages

Reference	Title
ASTM D4541	Standard Test Methods for Pull-Off Strength of Coatings on Metal Substrates Using Portable Adhesion Testers
ASTM 5402	Standard Practice for Assessing the Solvent Resistance of Organic Coatings Using Solvent Rubs
ASTM D6677	Standard Test Method for Evaluating Adhesion By Knife
ASTM D7234	Standard Test Method for Pull-Off Adhesion Strength of Coatings on Concrete Using Portable Adhesion Testers.
ASTM E337	Standard Test Method for Measuring Humidity With a Psychrometer
ASTM F22	Water Break Test
ASTM F1869	Standard Test Method for Measuring Moisture Vapor Emission Rate of Concrete Subfloor Using Anhydrous Calcium Chloride
ASTM F2170	Standard Test Method for Measuring Relative Humidity in Concrete Floor Slabs Using Insitu Probes.
FS 595b	Federal Standard Colors
ICRI 310.2	Guideline for Selecting and Specifying Concrete Surface Preparation for Sealers, Coatings, and Polymer Overlays
ISO 8502-3 (Part 3)	Assessment of Dust on Steel Surfaces Prepared for Painting (Pressure Sensitive Tape Method)
NACE Publication 6D-163	A Manual for Painter Safety
NACE Publication 6G-164 A	Surface Preparation Abrasives for Industrial Maintenance Painting
NACE Standards	National Association of Corrosion Engineers, TPC.
NACE Standard RP0188	Standard Recommended Practice – Discontinuity (Holiday) Testing of New Protective Coatings on Conductive Substrates
NAPF 500-03	Surface Preparation Standard for Ductile Iron Pipe and Fittings in Exposed Locations Receiving Special External Coatings and/or Special Internal Linings
NAPF 500-03-04	Abrasive Blast Cleaning for Ductile Iron Pipe
NAPF 500-03-05	Abrasive Blast Cleaning for Cast Ductile Iron Fittings
OSHA 1910.144	Safety Color Code for Marking Physical Hazards
OSHA 1915.35	Standards – 29CFR – Painting
SSPC-AB 1	Mineral and Slag Abrasives
SSPC-PA 1	Shop, Field, and Maintenance Painting of Steel
SSPC-PA 2	Measurement of Dry Coating Thickness with Magnetic Gages
SSPC-PA 9	Measurement of Dry Coating Thickness on Cementitious Substrates Using Ultrasonic Gages
SSPC-PA Guide 1	Guide for Illumination of Industrial Painting Project
SSPC-PA Guide 3	A Guide to Safety in Paint Application
SSPC-PA Guide 6	Guide for Containing Debris Generated During Paint Removal Operations
SSPC-PA Guide 11	Guide for Protecting Corners, Edges, Crevices and Irregular Steel Geometries by Stripe Coating
SSPC-SP 1	Solvent Cleaning
SSPC-SP 2	Hand Tool Cleaning
SSPC-SP 3	Power Tool Cleaning
SSPC-SP 5/NACE #1	White Metal Blast Cleaning
SSPC-SP 6/NACE #3	Commercial Blast Cleaning
SSPC-SP 7/NACE #4	Brush-Off Blast Cleaning
SSPC-SP 10/NACE#2	Near-White Blast Cleaning
SSPC-SP 11	Power Tool Cleaning to Bare Metal

Reference	Title
SSPC SP WJ-1/NACE WJ-1	Surface Preparation and Cleaning of Steel and Other Hard Materials by High and Ultra-High Pressure Water Jetting Prior to Recoating-Clean to Bare Substrate
SSPC SP WJ-2/NACE WJ-2	Surface Preparation and Cleaning of Steel and Other Hard Materials by High and Ultra-High Pressure Water Jetting Prior to Recoating-Very Thorough Cleaning
SSPC SP WJ-3/NACE WJ-3	Surface Preparation and Cleaning of Steel and Other Hard Materials by High and Ultra-High Pressure Water Jetting Prior to Recoating-Thorough Cleaning
SSPC SP WJ-4/NACE WJ-4	Surface Preparation and Cleaning of Steel and Other Hard Materials by High and Ultra-High Pressure Water Jetting Prior to Recoating-Light Cleaning
SSPC-SP 13/NACE #6	Surface Preparation of Concrete
SSPC-SP 16	Brush-off Blast Cleaning Non-Ferrous Metals
SSPC SP-CAB 1	Abrasive Blast Cleaning of Concrete and Cementitious Materials – Thorough Cleaning
SSPC SP-CAB 2	Abrasive Blast Cleaning of Concrete and Cementitious Materials – Intermediate Cleaning
SSPC SP-CAB 3	Abrasive Blast Cleaning of Concrete and Cementitious Materials – Brush Blast Cleaning
AMPP SP21548	Pressurized Water Cleaning of Concrete and Cementitious Materials- Thorough Cleaning
SSPC-TR2	Wet Abrasive Blast Cleaning
SSPC-TU-3	Overcoating
SSPC-Guide 15	Field Methods for Retrieval and Analysis of Soluble Salts on Substrates.
SSPC V2	Systems and Specifications: Steel Structures Painting Manual, Volume 2
SSPC-VIS 1	Visual Standard for Abrasive Blast Cleaned Steel
SSPC-VIS 3	Visual Standard for Power and Hand – Tool Cleaned Steel
SSPC-VIS 4	Visual Standards (Water-jetting)
SSPC-VIS 5	Visual Standards (Wet Abrasive Blast Cleaning)
WPCF Manual of Practice No. 17	Paints and Protective Coatings for Wastewater Treatment Facilities. Guide and Paint Application Specifications.
LEED	Leadership in Energy and Environmental Design

1.05 QUALITY ASSURANCE

A. Standardization:

1. Provide materials and supplies that are standard products of CSMs. Provide materials in each coating system from a single CSM.
2. The standard products of CSMs other than those specified may be acceptable when it is demonstrated to the Engineer that they are equal in generic resin type, composition, durability, range of film thickness, and usefulness, for the purpose intended. Requests for consideration of CSMs other than those specified in this Section will be considered, provided the following minimum conditions are met.
   a. The proposed coating system uses an equal or greater number of separate coats to achieve the required total DFT.
   b. The proposed coating system uses coatings of the same generic type as that specified including curing agent type.
   c. Include information listed in paragraph 1.07, demonstrating that the proposed CSM's product is equal to the specified coating system.

d. Provide a list of Contractor and CSM references for the proposed product in similar situations where the coating of the same generic type has been applied. Include the project name, city, state, owner, phone number of owner; coating system reference and number from this Section 09 90 00; type of facility in which it was used, generic coating type, and year coating was applied.

e. Alternate coating systems submitted by the Contractor must be approved by the Engineer. There is no guarantee that alternate systems will be approved, and this is left exclusively up to the discretion of the Engineer. At least 3 competitive products have been provided in this Specification. The Contractor is encouraged to submit one of the specified coating systems.

f. At any time when there is conflict between the CSM's product data and the COAT SPEC requirements regarding surface preparation, material application, or any other coating details, the more stringent requirements will take precedent.

B. Shop and Field Contractors Quality Control Requirements:

1. Prior to any work, hold a pre-construction meeting with the coating subcontractor and coating system manufacturer's technical representatives (CTR) to review the scope of work, the accepted submittals and any comments, and review all surface preparation, application, curing, mixing, storage, and overall QC and testing requirements. Provide a minimum of 48 hours' notice to the Engineer and Owner in case they desire to attend the meeting.
2. The Contractor is solely responsible for the workmanship and quality of the coating system installation by the Contactor's CSA. Inspections by the Construction Manager, the Engineer, the Owner, or the CTR will not relieve or limit the Contractor's responsibilities for the quality of the coating system.
3. Conform to requirements of this specification and the standards referenced in this Section. Changes in the coating system installation requirements will be allowed only with the written acceptance by the Engineer and CSM before work commences.
4. Only personnel who are trained by the CTR specifically for this contract or who are approved by the CSM specifically for this contract shall be allowed to perform the coating system installation specified in this Section. The CTR to verify in writing that the Contractor's personnel installing the coating systems covered by this Section have the appropriate training and/or experience to properly perform the coating systems work.
5. Provide a Quality Control Person (QCP) who is a certified NACE, SSPC, or AAMP Coatings Inspector with at least 5 years of experience inspecting coating work similar to the work covered by this Section. The QCP to perform all QC inspection testing and inspection tasks while fully documenting all efforts required by these specifications and/or additional CSM's requirements.
6. Do not use contaminated, outdated, diluted materials, and/or materials from previously opened containers.
7. For repairs, I provide the same products, or products recommended by the CSM, as used for the original coating.
8. Identify the points of access for inspection by the Owner, Engineer and/or Construction Manager. Provide ventilation, ingress and egress, and other means necessary for the Engineer, Owner, or Construction Manager's personnel to safely access the work areas.

9. Contractor's CSA to conduct the work so that the coating system is installed as specified and inspect the work continually to ensure that the coating system is installed as specified. Correct coating system work that does not conform to the specifications or is otherwise not acceptable to the as-specified requirements at no additional cost to the Owner.
10. Provide full time inspection with trained and certified quality control (QC) inspectors performing all QC procedures as the coating work proceeds in accordance with the requirements of this section. Minimum qualifications for QC inspectors on concrete projects is AMPP-CCI Level 1 with a minimum of 3 years' experience in QC processes, providing they are under the direct supervision of a AMPP Certified CCI Level 2 Concrete Coatings Inspector. On non-concrete related project, the minimum QC inspector is AMPP Basic Coating Inspector (NACE/SSPC Level 1) with a minimum of 3 years' experience in QC processes, providing they are under the direct supervision of a AMPP Certified Coatings Inspector (NACE/SSPC Level 2) or AMPP Senior Coatings Inspector (NACE/SSPC Level 3) in good standing, with at least 10 years of similar coatings work experience. An AMPP Basic Coating Inspector (NACE/SSPC Level 1) with a minimum of 3 years' experience in QC processes, providing they are under the direct supervision of a AMPP Certified Coatings Inspector (NACE/SSPC Level 2) or AMPP Senior Coatings Inspector (NACE/SSPC Level 3) in good standing, with at least 10 years of similar coatings work experience may be acceptable providing the AMPP Basic, AMPP Certified and AMPP Senior coating inspectors can each can show verifiable proof of performing inspection successfully on 5 verifiable concrete projects similar in size and scope as the project that is part of this specification.
11. The Contractor's QC personnel to measure DFT of metal surfaces as per SSPC-PA2. Take measurements as often as necessary to ensure the DFT requirements of the specification are met. Measure DFT of metallic surfaces using Type II Magnetic (Ferrous) and Type II Eddy Current Non-Ferrous) Dry Film Thickness gauges. Use only gauges calibrated within 1 year of use. Perform testing of DFT on concrete substrates as per SSPC-PA9 using Ultrasonic DFT gauges or another suitable method (e.g., Calculating material usage vs square feet coverage) to ensure DFT requirements are met.
12. Contractor/CSA to submit for approval a QCTIP for the work covered by this Section. List all tests and inspection tasks in the QCTIP including referenced and applicable standards to be conducted and the frequency in which these tests or tasks will be performed. This frequency can be addressed for certain tests such as air and substrate temperature or dew point on an hourly per shift basis. Or this frequency can be addressed on a per number of square feet basis for tests and tasks such as wet and DFT tests or adhesion tests. Include in the QCTIP a written record which identified when (time and date) work not conforming to the specification requirements is identified, a written record of the proposed corrective actions for such non-conforming work and a record of when that action was performed (time and date). Describe all corrective action for non-conforming work in detail with referenced digital photographs taken of the re-work for subsequent review by the Owner's representative.

13. Complete the Coating System Quality Control Checklist, Form 09 90 00-A, included in Section 09 90 00 –Part 4 for coating system installations. Follow the sequential steps required for proper coating system installation as specified and as listed in the Coating System Quality Control Checklist. For each portion of the work, install the coating system, document all QC measures performed, and complete sign-offs as specified prior to proceeding with the next step. After completing each step as indicated on the Coating System Quality Control Checklist, sign the checklist indicating that the work has been installed and inspected as specified and attach a final copy of all individual QC checks or test results as applicable and required.
14. Submit a daily QC inspection report from the QCP that describes and documents all QC tests and inspection tasks performed including frequency of performance and test results (including test data) and referenced standard followed for each shift the CSA works. Submit these reports on the morning of the following day the work was performed to the Construction Manager. Include with the daily QC report a written account of all non-conforming work, subsequent corrective measures and annotated digital photographs. Submit a standard inspection form to be used for these reports for review by the Engineer. CSA's QC Inspector to use approved inspection report forms to record all QC inspection and testing throughout the performance of the coating work.

C. Quality Control Hold Points:
   1. The Contractor's QCP to conduct QC inspections of the coating work as it proceeds to meet all specified quality requirements. In addition, conduct inspection at Hold Points during the coating system installation and record the results on Form 09 90 00-A. Coordinate Hold Points with the CTR, Engineer and Construction Manager so they Construction Manager or Engineer may observe the Quality Control inspections on a scheduled basis. Provide the Construction Manager or Engineer a minimum of 1 days' notice prior to conducting Hold Point Inspections. The Hold Points shall be as follows:
      a. Environment and Site Conditions. Prior to commencing an activity associated with coating system installation, measure and record ambient air temperature and humidity as well as other conditions such as proper protective measures for surfaces not to be coated and safety requirements for personnel. Confirm the weather and/or environmental conditions within the structure comply with the requirements specified by the CSM.
      b. Conditions Prior to Surface Preparation. Prior to commencing surface preparation, perform cleaning to remove all oil, grease, dirt, soluble salts, and all other foreign contaminants from the surface.
      c. Monitoring of Surface Preparation. Spot check degree of cleanliness, surface profile, and surface pH testing, as required. Confirm compressed air used for surface preparation or blow down cleaning is free from oil and moisture.
      d. Post Surface Preparation. Upon completion of the surface preparation, measure and inspect for proper degree of cleanliness and surface profile as specified in this Section 09 90 00 and in the CSM's written instructions.
   2. After surface preparation and prior to the application of primer and coatings the surfaces the CSA must ensure that any remaining dust meets the acceptable level of the specification requirements.
      a. Monitoring of Coatings Application. Inspect, measure, and record the WFT and general film quality (visual inspection) for lack of runs, sags, pinholes, holidays, etc. as the application work proceeds.

b. Post Application Inspection. Identify defects in application work including pinholes, holidays, excessive runs or sags, inadequate or excessive film thickness, and other problems as may be observed.

c. Post Cure Evaluation. Measure and inspect the overall DFT. Conduct a DFT survey, and perform adhesion testing, holiday detection, or cure testing as required based on the type of project and the specific requirements in this Section 09 90 00 and/or in the CSM's written instructions.

d. Follow-up to Corrective Actions and Final Inspection. Measure and reinspect corrective coating work performed to repair defects identified at prior Hold Points. Include final visual inspection along with follow-up tests such as holiday detection, adhesion tests, and DFT surveys.

D. Responsibilities of the CTR:

1. General:

a. Provide the services of the CTR to be on site to routinely verify in writing that the application personnel have successfully performed representative portions of the surface preparation, filler/surface application, coating system application, and QC Inspection in accordance with this Section 09 90 00. Include testing or witnessing the contractors testing for the required degree of cleanliness, surface pH for concrete substrates, surface profile of substrates, proper mixing of coating materials, application (including checking the wet and DFT of the coating systems), proper cure of the coating systems, and proper treatment of coating systems at terminations, transitions, and joints and cracks in substrates. These inspections are not expected to be full-time, but rather to assure that inspections by the CTR are performed on representative portions of all major steps of the coating work to ensure the CSM approves those representative portions of the work to be in compliance with the CSM's recommendations and instructions. This inspection is in addition to the inspection performed by the Contractor in accordance with paragraph 1.05C of this section. The CTR shall provide a reasonable level of oversight of the contractor's QC processes to be representative of key steps in the work, at their discretion, to provide a final sign-off certification that the CSM's products have been properly installed.

2. Coating System Inspection:

a. The CTR shall verify representative steps of the coating work are performed properly per the manufacturer's instructions; the CTR shall coordinate and confirm the planned inspections by the Contractor's QCP are being performed per the QCTIP to assure quality of the work meets the requirements of both these specifications and any additional manufacturer's requirements; and the CTR shall verify or witness the contractors QC processes of the following QC steps at their discretion:

1) Inspect ambient conditions during various coating system installation at hold points for conformance with the specified requirements.

2) Inspect the surface preparation of the substrates where the coating system will terminate or will be applied for conformance to the specified application criteria.

3) Inspect preparation and application of coating detail treatment (for example, terminations at joints, metal embedments in concrete, and other terminations at different substrates).

4) Inspect application of the filler/surface materials for concrete and masonry substrates.
5) Inspect application of the primers and finish coats including WFT and DFT of the coatings.
6) Inspect coating systems for cure.
7) Review adhesion testing of the cured coating systems for conformance to specified criteria.
8) Inspect and record representative localized repairs made to discontinuities identified via continuity testing.
9) Conduct a final review of completed coating system installation for conformance to the specifications.
10) CTR to prepare and submit a site visit report following each site visit that documents the acceptability of the coating work in accordance with the CSM's recommendations.

3. Final Report:
   a. Upon completion of coating work for the project, the CTR shall prepare a letter summarizing the inspection findings and shall attach the site visit reports required in 1.05 D.2. a.10. Include a statement that the completed work was performed in accordance with the requirements of this Section 09 90 00 and the CSM's recommendations based on the inspections performed by the CTR.

1.06 DELIVERY AND STORAGE

A. General:
1. Procedures: In accordance with Section 01 66 00.
2. Deliver materials to the job site in their original, unopened containers. Properly label each container P. Handle and store materials to prevent damage to or loss of label, meeting the project requirements or the CSM's if more stringent.
3. Include the following information on material container labels.:
   a. Name or title of product
   b. CSM's batch number
   c. CSM's name
   d. Generic type of material
   e. Application and mixing instructions
   f. Hazardous material identification label
   g. Shelf-life expiration date
4. Store materials in enclosed structures protected from weather and excessive heat or cold in accordance with the CSM's recommendations. Store flammable materials in accordance with state and local requirements.
5. Clearly mark containers indicating personnel safety hazards associated with the use of or exposure to the materials.
6. Provide Safety Data Sheets (SDS) for each material to the Construction Manager.
7. Store and dispose of hazardous waste including waste solvents and coatings, according to federal, state and local requirements.

1.07 SUBMITTALS:

A. Action Submittals:

1. Provide in accordance with Section 01 33 00:

a. A copy of this specification section, with addendum updates included, and 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 or those parts which are to be provided by the Contractor or others. Check marks denote full compliance with a paragraph as a whole. If deviations from the specifications are indicated, and therefore requested by the Contractor, underline each deviation and denote by a number in the margin to the right of the identified paragraph, and provide a detailed explanation of the reasons for requesting the deviation. Engineer is the final authority for determining acceptability of requested deviations. The remaining portions of the paragraph not underlined signifies compliance on the part of the Contractor with the specifications. Failure to include a copy of the marked-up specification sections along with justification(s) for requested deviations to the specification requirements is cause for rejection of the entire submittal and no further submittal material will be reviewed.

b. CSM's current printed recommendations and product data sheets for coating systems including:

1) VOC data
2) Surface preparation recommendations
3) Primer type, where required
4) Maximum dry and wet film mil thickness per coat
5) Minimum and maximum curing time between coats, including atmospheric conditions limitations for each (temperature, dewpoint difference from temperature, etc.)
6) Curing time before exposure to elements
7) Thinner to be used with each coating
8) Ventilation requirements
9) Minimum atmospheric conditions during which the paint shall be applied
10) Allowable application methods
11) Maximum allowable moisture content
12) Maximum shelf life

c. Affidavits signed and sealed by an officer of the CSM's corporation, attesting to full compliance of each coating system component with current and promulgated federal, state, and local air pollution control regulations and requirements.

d. Safety Data Sheets (SDS) for materials to be delivered to the job site, including coating system materials, solvents, and abrasive blast media.

e. List of cleaning and thinner solutions allowed by the CSMs.

f. Storage requirements including temperature, humidity, and ventilation for Coating System Materials as recommended by the CSMs.

g. CSM's detailed, written instructions for coating system treatment and graphic details for coating system terminations in the structures to be coated including, but not limited to, pipe penetrations, metal embedments, and other terminations to be determined from the contract drawings. Include detailed treatment for coating system at joints/terminations in concrete and concrete masonry unit assemblies.

h. CSM's detailed maximum chloride level tolerance for all coatings to be applied on metallic surfaces.

i. Provide a minimum of 5 project references each for the Contractor and CSA including contact name, address, and telephone number where similar coating work has been performed by their companies in the past 5 years.

j. The QCITP as specified in Article 1.05 D 2 and including all pertinent QC requirements covered in the Quality Control Table 09 90 00 – 1 found under Part 4 of this Section. Include:

   1) the QC Inspection Forms

   2) A list of who is responsible for performing and documenting all QC tests and inspection tasks.

k. Shop primer product data sheet and letter stating that shop primer is compatible with the field applied topcoats for all equipment on other items.

l. A daily QC inspection report from the QCP that documents all QC tests and inspections performed and their results for each day of the work. Document all non-compliant work for coating repair. Coordinate the report with the QCTIP provided per 1.05 C.1. Deliver daily QC report electronically to the Construction Manager and Engineer the morning of the following day.

m. Submit a Flash Report (see definitions section for Flash Report definition) from the QCP immediately identifying any items or issues that require immediate attention to the project Engineer

n. Letter from CTR confirming that Contractor's personnel to perform coating work have been trained or have appropriate experience to perform the work covered by this Section.

o. Resume of the Contractor's QCP responsible for performing the QC Testing and Inspection tasks delineated in the Contractor's Inspection and Testing Plan.

B. Informational Submittals:

1. Procedures: Section 01 33 00.
2. Prior to application of coatings, submit letter(s) from the CTR(s) identifying the application personnel who have satisfactorily completed training as specified in Article 1.05 or a letter from the CSM stating that personnel who shall perform the work are approved by the CSM without need for further or additional training.
3. Submit reports specified in Article 1.05 while the work is underway.

C. Closeout Submittals:

1. Procedures: Section 01 33 00
2. Submit the Coating System Quality Control Checklists using Form 09 90 00-A, for the coating work.

D. Product substitution requests:

1. Refer to the General Conditions and/or General Requirements for substitution requests procedures for materials or requests to substitute other specification requirements, which are handled differently than the normal project submittal procedures.

PART 2 PRODUCTS

2.01 MATERIALS

A. General:

1. Notwithstanding the listing of product names in this Section 09 90 00, provide affidavits, signed and sealed by an officer of the CSM's corporation, attesting to full compliance of each coating system component with current and promulgated federal, state, and local air pollution control regulations and requirements. See Section 1.05 for detailed QC requirements required by the contractor. Do not apply coatings to a surface until the specified affidavits have been submitted, reviewed and accepted. Failure to comply with this requirement is cause for rejection and removal of such materials from the site.
2. The following list specifies the material requirements for coating systems. Coating systems are categorized by generic name followed by an identifying abbreviation. If an abbreviation has a suffix number, it is for identifying subgroups within the coating system.

Material Requirements for Coating Systems: All of the United States including California Except SCAQMD

Coating System	CSM	First Coat(s)	Finish Coat(s)
Epoxy Coatings			
E-1	AkzoNobel	Interseal 670HS	Interseal 670HS
	Carboline	Carboguard 890	Carboguard 890
	PPG	Amerlock 2/400 Series	Amerlock 2/400 Series
	Sherwin Williams	Macropoxy 646 FC	Macropoxy 646 FC
	Tnemec	Series V69	Series V69
E-2	AkzoNobel	Interseal 670HS	Interseal 670HS
	Carboline	Carboguard 890 series	Carboguard 890 series
	PPG	Amerlock 2/400 Series	Amerlock 2/400 Series
	Sherwin Williams	Dura-Plate 235	Dura-Plate 235
	Tnemec	Series V69	Series V69
E-3	AkzoNobel	Interseal 670HS	Interseal 670HS
	Carboline	Carboguard 890 series	Carboguard 890 series
	PPG	Amerlock 2/400 Series	Amerlock 2/400 Series
	Sherwin Williams	Dura-Plate 235	Dura-Plate 235
	Tnemec	Series V69	Series V69
E-4	AkzoNobel	Interseal 670HS	Interseal 670HS
	Carboline	Carboguard 890	Carboguard 890

Material Requirements for Coating Systems: All of the United States including California Except SCAQMD

Coating System	CSM	First Coat(s)		Finish Coat(s)
	PPG	Amerlock 2/400 Series		Amerlock 2/400 Series
	Sherwin Williams	Macropoxy 646 FC		Macropoxy 646 FC
	Tnemec	Series V69		Series V69
Elastomeric Acrylic Coatings				
ELA-1	Carboline	Flexxide Elastomer		Flexxide Elastomer
	PPG	Seal Grip 17-921 XI Series		Perma-Crete Pitt-Flex 4-110XI (interior/exterior elastomeric coating)
	Sherwin Williams	Loxon XP or Loxon Concrete & Masonry Primer		Loxon XP
	Tnemec	Series 156		Series 156
Epoxy Polyurethane				
EU-1	AkzoNobel	Interzinc 52 Series	Intergard 251HS	Interthane 990 Series
	PPG	Amercoat 68 HS	Amerlock 2/400 Series	Pithane Ultra
	Carboline	Carbozinc 859 series	Carboguard 890	Carbothane 134 series
	Sherwin Williams	Galvapac 1K Zinc	Macropoxy 646FC	Hi Solids Polyurethane 250
	Tnemec	Tneme-Zinc 90G-1K97	Series V69	Series 1094
Flooring Systems				
EFL-1	PPG	PPG Flooring 912LV – 8-10 mils	PPG Novaguard 5041 –12-15 Mils with 20/40 Mesh Aggregate Broadcast	PPG Novaguard 5041 – 12-15 Mils
	Sherwin Williams	Resuprime 3579 –8-10 mils	Resufloor 3741 – 12-15 Mils with 20/40 Mesh Aggregate Broadcast	Resufloor 3741 – 12-15 mils
	Tnemec	Chemtread 239 – 8-10 Mils	Chemtread 239 – 12-15 mils with 50/70 Mesh Aggregate Broadcast	Tneme-Glaze 282 – 12-15 Mils
EFL-2	PPG	PPG Flooring 912LV – 8-10 mils	PPG Flooring 610SL –12-15 mils with 20/40 Mesh Aggregate Broadcast	PPG Flooring 610SL – 12-15 mils
	Sherwin Williams	Resuprime 3579 –8-10 mils	Resufloor 3746 – 12-15 mils with 20/40 Mesh Aggregate Broadcast	Resufloor 3746 – 12-15 mils
	Tnemec	Power-Tread 237-8-10 mils	Power-Tread 237- 12-15 mils with 50/70 Mesh Aggregate Broadcast	Tneme-Glaze 280 –12-15 Mils
EFL-3	PPG	PPG Flooring 912LV – 8-10 mils	PPG Flooring 610SL –12-15 mils with 20/40 Mesh Aggregate Broadcast	PPG Flooring 688 – 9.6-12 mils
	Sherwin Williams	Resuprime 3579 –8-10 mils	Resufloor 3746 – 12-15 mils with 20/40 Mesh Aggregate Broadcast	Resutile HTS 100 – 3-4 mils

Material Requirements for Coating Systems: All of the United States including California Except SCAQMD

Coating System	CSM	First Coat(s)		Finish Coat(s)
	Tnemec	Power-Tread 237-8-10 mils	Power-Tread 237- 12-15 mils with 50/70 Mesh Aggregate Broadcast	Everthane 248 2-3 mils
EU-1-FRP	AkzoNobel	Interseal 670HS		Interthane 990 Series
	PPG	Amercoat 2/400 Series		Pithane Ultra
	Carboline	Carboguard 890		Carbothane 134 series
	Sherwin Williams	Macropoxy 646FC		Hi Solids Polyurethane 250
	Tnemec	Series V69		Series 1095
Latex Acrylic				
L-1	Benjamin Moore	SuperKote 3000 Primer		Corotech V331 Acrylic
	Carboline	Sanitile 120		Carbocrylic 3359 MC
	PPG	Pitt-Tech Plus 4020 PF		Pitt-Tech Plus 4216
	Sherwin Williams	Loxon Acrylic Primer		Sher-Cryl HPA
	Tnemec	Series 1028 or 1029		Series 1028 or 1029
L-2	Benjamin Moore	Series 110 Stix Primer		Corotech V331 DTM Acrylic
	Carboline	Sanitile 120		Carbocrylic 3359 MC
	PPG	Pitt-Tech Plus 4020 PF		Pitt-Tech Plus 4216
	Sherwin Williams	Pro-Cryl Primer		Sher-Cryl HPA
	Tnemec	Series 1028 or 1029		Series 1028 or 1029
L-3	Benjamin Moore	Corotech V331 DTM Acrylic		Corotech V331 DTM Acrylic
	Carboline	Carbocrylic 3359 DTMC		Carbocrylic 3359 DTMC
	PPG	Pitt-Tech Plus 4020 PF		Pitt-Tech Plus 4216
	Sherwin Williams	Pro-cryl Primer		Sher-Cryl HPA
	Tnemec	Series 1028 or 1029		Series 1028 or 1029
Penetrating Stain				
S-1	Sherwin Williams	H&C Color Top		H&C Color Top
	PPG	NA		Permacrete 4-4210XI Series
	Tnemec	Series 617		Series 617
S-2	Curecrete Chemical Company	N/A		Ashford Formula
	Sherwin Williams	N/A		Conflex 7% Silane Sealer
	PPG	Permacrete 4-6100C		Permacrete 4-6100C
	Tnemec	N/A		Series 633 Prime-A-Pell H2O
S-3	Sherwin Williams	N/A		Conflex 7% Siloxane
	PPG	Permacrete 4-6100C		Permacrete 4-6100C

Material Requirements for Coating Systems: All of the United States including California Except SCAQMD			
Coating System	CSM	First Coat(s)	Finish Coat(s)
	Tnemec	N/A	Series 633 Prime-A-Pell H2O

**See CSM's Product Data Sheets for acceptable thinners for VOC compliance or do not thin.*

PART 3 EXECUTION

3.01 COATINGS

A. General:

1. Do not use coating products until the Engineer, Construction Manager, Owner, or Owner's Representative has accepted the affidavits specified in paragraphs 1.07 and 2.01 and the CTR has trained the Contractor and CSA in the surface preparation, mixing, and application of each coating system.
2. Erect and maintain protective enclosures as stipulated per SSPC-Guide 6 Guide for Containing Debris Generated During Paint Removal Operations.
3. Only use primers accepted as part of the coating submittal for the specific project components, including for shop applied primers.

B. Shop and Field Coats:

1. Shop Applied Prime Coat: Except as otherwise specified, prime coats may be shop-applied or field-applied. Use only shop-applied primers which have been identified and accepted as part of the coating submittal. It must be compatible with the specified coating system and applied at the minimum DFT recommended by the CSM. Provide data sheets identifying the shop primer as a Submitted for Approval as required in Article 1.07. All requirements for surface preparation, inspections and testing, and documentation apply to shop applied primers. Perform adhesion tests on the shop primer as specified in paragraph 3.01 B.3. Adhesion Confirmation. Remove damaged, deteriorated and poorly applied shop coatings that do not meet the requirements of this Section 09 90 00 and the surfaces recoated. If the shop primer coat meets the requirements of this Section 09 90 00, the field coating may consist of touching up the shop prime coat and then applying the finish coats to achieve the specified film thickness and continuity.
2. Field Coats: Apply field coats consisting of one or more prime coats and one or more finish coats to build up the coating to the specified coating system DFT. Unless otherwise specified, do not apply finish coats until other work in the area is complete and previous coats have been inspected.
3. Adhesion Confirmation: Perform an adhesion test after proper cure in accordance with ASTM D3359 to demonstrate that (1) the shop applied prime coat adheres to the substrate and (2) the specified field coatings adhere to the shop applied coat. Test results showing an adhesion rating of 4A or better on surfaces are required for coatings 5 mils or more in thickness (Method A). Test results showing an adhesion rating of 4B or better on other surfaces are acceptable for coating thicknesses less than 5 mils.

4. Test compatibility of coatings applied over existing coatings of different generic chemistry for compatibility through test patches applied and provided time for cure. After suitable cure time as per the CSM, perform adhesion testing as per 3.01.B.3 prior to proceeding.

C. Application Location Requirements:
   1. Equipment, non-immersed, non-corrosive atmosphere: For items of equipment, or parts of equipment that are not immersed in service, shop prime and then finish coat in the field after installation with the specified or acceptable color. If the shop primer requires top coating within a specified period, finish coat the equipment in the shop and then touch-up paint after installation in the field. If equipment removal and reinstallation is required for the project, touch-up coating the field following reinstallation.

3.02 PREPARATION

A. General:
   1. Prepare each type of surface in accordance with the specific requirements of each coating specification sheet (COATSPEC) and the following. In the event of a conflict, the more stringent requirements shall take precedence.
   2. Clean and dry surfaces to be coated. Before applying coating or surface treatments, remove oil, grease, dirt, rust, mill scale, old, weathered coatings, and other foreign substances. Remove oil and grease before mechanical cleaning. Where testing reveals chloride contamination, remove chlorides prior to blast cleaning or other mechanical surface preparation methods. Where mechanical cleaning is accomplished by blast cleaning, wash, grade, and free the abrasive from contaminants that might interfere with the adhesion of the coatings. Use air for blast cleaning that is free of oil and moisture so as not to cause detrimental contamination of the surfaces to be coated.
   3. Protect all surfaces and equipment not to be coated from dust and overspray. Schedule cleaning and coating so that dust and spray from the cleaning process shall not fall on wet, newly coated surfaces. Remove or mask hardware, hardware accessories, nameplates, data tags, machined surfaces, sprinkler heads, electrical fixtures, and similar uncoated items which are in contact with coated surfaces prior to surface preparation and coating operations. Reinstall removed items following completion of coating. Disconnect and move equipment adjacent to walls to permit cleaning and coating of equipment and walls. Replace and reconnect items following coating.

B. Blast Cleaning:
   1. Meet the following requirements for abrasive blast cleaning:
      a. Do not reuse blast abrasive. Do not use silica sand for the blast abrasive. Use blast abrasive media which provides the most efficient cutting action to achieve the profile and degree of cleanliness specified.
      b. Filter compressed air used for blast cleaning and ensure it contains no condensed water or oil. Clean moisture traps at least once every 4 hours or more frequently as required to prevent moisture from entering the supply air to the abrasive blasting equipment.

c. Install oil separators just downstream of compressor discharge valves and at the discharge of the blast pot discharges. Check and clean oil separators on the same frequency as the moisture traps as defined above.

d. Regulators, gauges, filters, and separators must be in use on compressor air lines to blasting nozzles at all times during this work.

e. Install an air dryer or desiccant filter drying unit which dries the compressed air prior to blast pot connections. Use and maintain the dryer for the duration of surface preparation work.

f. Use abrasive blast nozzles of the venturi or other high velocity type supplied with a minimum of 100 pounds per square in gauge (psig) air pressure and sufficient volume to obtain the blast cleaning production rates and cleanliness specified.

g. Provide ventilation for airborne particulate evacuation (meeting pertinent safety standards) to optimize visibility for both blast cleaning and inspection of the substrate during surface preparation work.

h. If, between final surface preparation work and coating system application, contamination of prepared and cleaned metallic substrates occurs, or if the prepared substrates' appearance darkens or changes color, reclean the surface by water jetting and/or abrasive blast cleaning until the specified degree of cleanliness is reclaimed.

i. Protect mechanical, electrical, and other equipment adjacent to and surrounding the work area from dusts, overspray and general damage.

C. Solvent Cleaning:

1. Use emulsifying type solvent wash, solvent wipe, or cleaners , including but not limited to those used for surface preparation in accordance with SSPC-SP 1 Solvent Cleaning, which emit no more than [340 g/l VOCs for AIM regions], [250 g/l for CARB regions], [100 g/l for SCAQMD regions], contains no phosphates, is biodegradable and is compatible with the specified primer.

2. Use clean white cloths and clean fluids in solvent cleaning.

D. Metallic Surfaces:

1. Prepare metallic surfaces in accordance with applicable portions of surface preparation specifications of the Society for Protective Coatings (SSPC) and NACE International (NACE) specified for each coating system. See Coat Spec for each coating system in this Section 09 90 00. The profile depth of the surface to be coated shall be in accordance with the COATSPEC requirements in this Section measured by Method C of ASTM D4417. Select blast particle size to produce the specified surface profile. Use solvent in solvent cleaning operations as recommended by the CSM.

2. Take the following steps if soluble chloride contamination is suspected or is possible/plausible. Following initial blast cleaning of steel substrates, test for the presence of soluble chlorides using the retrieval and analysis method designated as Method 4.2.2. Adhesively Bonded Latex Patch or Cell as described in SSPC-TG15. Test accordance with ISO 8502-6/8502-9 at the rate of 4 tests per 1,000 sq. ft. of steel surface area to be coated, but no less than a total of 4 tests per component. The target threshold or tolerance conductivity level for soluble chloride contamination shall be approved in writing by the CSM's CTR for each product that is part of the application.

3. Prepare metallic surfaces based upon comparison with SSPC-VIS1-89 (ASTM D2200) and as described in the COATSPEC for each coating system. If dry abrasive blast cleaning is selected and to facilitate inspection, on the first day of cleaning operations, provide abrasive blast metal reference panels meeting the standards specified for acceptance by the Construction Manager. Plates shall measure a minimum of 8-1/2 inches by 11 inches. Panels accepted by the Construction Manager as meeting the requirements of the specifications shall be initialed by the Contractor and the Construction Manager and coated with a clear non-yellowing finish. Provide a reference panel for each type of abrasive blasting to be used as the comparison standard throughout the project.
4. Blast cleaning requirements for steel, ductile iron, and stainless steel substrates are as follows:
    a. Prepare steel piping in accordance with SSPC-SP 6/NACE#3 (Commercial Blast Cleaning) and prime before installation. Prepare ductile iron piping surfaces including fittings in accordance with NAPF 500-03, NAPF 500-03-04, and NAPF 500-03-05.
    b. Abrasive blast clean stainless steel surfaces in accordance with SSPC-SP 16 to leave a clean uniform appearance with a minimum uniform surface profile of 1.5 to 2.5 mils, unless required to be greater by the CSM.
    c. Remove traces of grit, dust, dirt, rust scale, friable material, loose corrosion products or embedded abrasive from substrate by vacuum-cleaning prior to coating application. Blow down cleaning with compressed air is not permitted.
    d. Prevent contamination of the surface after blasting from worker's fingerprints, deleterious substances on workers' clothing, or from atmospheric conditions.
    e. Continuously monitor and maintain ambient environmental conditions in the enclosure to ensure the degree of cleanliness is held and no "rust back" occurs prior to coating material application.
5. Abrasive blast clean galvanized steel surfaces per SSPC SP 16 to produce a minimum surface profile of 1.0 to 1.5-mil profile and to remove all corrosion products. Caution–follow CSM's specific recommendations for surface prep, including abrasive blast cleaning.

E. Concrete Surfaces:
1. Inspect concrete surfaces prior to surface preparation and prepare concrete surfaces in accordance with SSPC-SP 13/SP CAB/NACE #6 (also called NACE 6).
2. Prior to surface preparation for degree of cleanliness and profile, prepare substrate cracks and areas requiring resurfacing and perform detail treatment including but not limited to, terminating edges per CSM recommendations.
3. Evaluate the surface profile for prepared concrete surfaces to be coated by comparing the profile of the prepared concrete with the profile of the ICRI 310.2 (molded surface profile replicas). Prepare surface profile in accordance with the COATSPEC requirements and the CSM's recommendations.
4. Inspect prepared concrete substrates for surface cleanliness after cleaning, preparation, and/or drying, but prior to making repairs or applying a coat in the coating system. Reinspect repaired concrete surfaces for cleanliness prior to application of the coating system.

5. Prepare concrete substrates using methods such as dry abrasive blast cleaning, high, or ultra-high-pressure water jetting in accordance with SSPC-SP 13 /SP CAB /NACE #6 to meet the following requirements:
    a. A clean substrate that is free of calcium sulfate, loose coarse or fine aggregate, laitance, loose hydrated cement paste, and otherwise deleterious substances.
    b. Open up air voids or bugholes to expose their complete perimeter by blast cleaning or other methods. Leaving shelled over, hidden air voids beneath the exposed concrete surface is not acceptable.
    c. Concrete substrate must be dry prior to the application of repair mortars, filler/surfaces, or coating system materials.
    d. Produce a concrete surface with a minimum pH of 9.0 to be confirmed by surface pH testing. If after surface preparation, the surface pH remains below 9.0, perform additional water blasting, cleaning, or abrasive blast cleaning until additional pH testing indicates an acceptable pH level.
    e. Following inspection of the concrete surface preparation, thoroughly vacuum clean concrete surfaces to be coated to remove loose dirt, and spent abrasive (if dry blast cleaning is used) leaving a dust free, sound concrete substrate.
    f. Remove debris produced by blast cleaning from the structures to be coated and dispose of legally off site.
6. Should abrasive blast cleaning or high or ultrahigh pressure water jetting not remove degraded concrete, use chipping or other appropriate tools to remove the deteriorated concrete until a sound, clean substrate is achieved which is free of calcium sulfate, loose coarse or fine aggregate, laitance, loose hydrated cement paste, and otherwise deleterious substances. Do not use equipment that will damage the underlying sound concrete such as pneumatic or electric chipping tools which will bruise or cause micro-cracking of the concrete substrate. Concrete substrates must be dry prior to the application of polymer based or mortars or filler/surfacers coating system materials.
7. Test moisture content of concrete to be coated in accordance with ASTM D4263, Standard Test Method for Indicating Moisture in Concrete by the Plastic Sheet Method at least once for every 500 sq. ft. of surface area to be coated. The presence of any moisture on plastic sheet following test period constitutes a non-acceptable test.
8. If moisture is detected, the CSA in cooperation with the CTR shall perform additional moisture testing vis ASTM F1869 or ASTM F2170 to determine the extent of the moisture vapor transmission. The acceptable limit for the application of barrier coatings for ASTM F1869 is < 3lbs/1,000 sq ft/24 hours. The acceptable limit as per ASTM F2170 is an RH value <70 percent.

F. Masonry Surfaces:
1. Prepare masonry surfaces such as Concrete Masonry Units (CMU) to remove chalk, loose dirt, dried mortar splatter, dust, peeling, or loose existing coatings, or otherwise deleterious substances to leave a clean, sound substrate.
2. Confirm masonry surfaces are dry prior to coating application. If pressure washing or low-pressure water blast cleaning or water jetting is used for preparation, allow the masonry to dry. Assess moisture content by the CTR to ensure moisture levels are in tolerance ranges suitable to the coating system being applied prior to coating application work proceeding. Provide Results and CTR to the Engineer or Construction Manager in writing from the CTR before proceeding with application.

G. Fiberglass Reinforced Plastic (FRP) Surfaces:

1. Prepare FRP surfaces by first sanding to establish uniform surface roughness without any gloss remaining while minimizing any excessive removal of resin material. Second, vacuum clean to remove loose FRP dust, dirt, and other materials. Do not use compressed air. Then Solvent clean using clean white rags and allow solvent to evaporate completely before application of coating materials.

H. Existing Facilities:

1. Unless otherwise specified, existing coating systems damaged by new construction shall be repaired and coated in accordance with the appropriate system specified for new work, with confirmation by the CSM that the specified coating will be compatible with the existing system.
2. Contractor shall demonstrate that the existing coating is compatible with field coating by performing the adhesion test specified in paragraph 3.01 Adhesion Confirmation. Where unacceptable test results are obtained, the Contractor shall follow manufacturer's written instructions as to the necessity of existing coating removal or the need for a tie coat to provide a satisfactory bond between the existing coating and the specified field coating."

3.03 APPLICATION

A. Workmanship:

1. Apply coats to produce an even film of uniform thickness free from runs, drips, sags, ridges, waves, laps, and brush marks and completely coating corners and crevices.
2. Use equipment designed for application of the materials specified. Equip compressors with suitable traps and filters to remove water and oils from the air. Perform a paper blotter test when requested by the Construction Manager or Engineer to determine if the air is sufficiently free of oil and moisture so as not to produce deteriorating effects on the coating system. Limit the amount of oil and moisture in spray air to be less than the limits recommended by the CSM. Equip spray equipment with mechanical agitators, pressure gages, pressure regulators, and spray nozzles of the proper sizes.
3. Apply each coat evenly and sharply cut to line. Avoid over-spraying or spattering paint on surfaces not to be coated. Protect glass, hardware, floors, roofs, equipment, and all other adjacent areas and installations by taping, drop cloths, or other suitable masking measures.
4. Use coating applications method -- conventional or airless spray, plural component spray, brush or roller, or trowel -- as recommended by CSM.
5. Allow each coat to cure or dry thoroughly, according to CSM's printed instructions, prior to recoating.
6. Lightly sand glossy undercoats to provide a surface suitable for the proper application and adhesion of subsequent coats. Vary color for each successive coats for coating systems wherever possible to provide visual confirmation of coverage.
7. Prior to overall coating system application on complex steel shapes, stripe coat welds, edges of structural steel shapes, metal cut-outs, pits in steel surfaces, or rough surfaces as per SSPC PA Guide 11 with the primer coat material using brushes or rollers to ensure proper coverage. Stripe coat via spray application is not permitted.

B. Coating Properties, Mixing and Thinning:

1. Coatings, when applied, shall provide a satisfactory film and smooth even surface. Thoroughly stir, strain, and keep at a uniform consistency all coating materials during application. Mix coating materials consisting of 2 or more components in accordance with the CSM's instructions. Where necessary to suit the conditions of the surface, temperature, weather, and method of application, the coating may be thinned but only as recommended by the CSM. The VOC of the coating as applied shall comply with prevailing air pollution control regulations. Unless otherwise specified, do not reduce coating materials more than necessary to obtain the proper application characteristics. Use thinner as recommended by the CSM.

C. Atmospheric Conditions:

1. Apply coatings only to surfaces that are dry and only under conditions of evaporation rather than condensation. Do not apply coating systems during rainy, misty weather, or to surfaces upon which there is frost or moisture condensation. During damp weather, when the temperature of the surface to be coated is within 10 degrees F of the dew point, forced dehumidification equipment may be used to maintain a temperature of minimum 40 degrees F and 10 degrees F above the dew point for the surfaces to be coated, the coated surface, and the atmosphere in contact with the surface. Maintain these conditions for a period of at least 8 hours or as recommended by the CSM. Where conditions causing condensation are severe, use dehumidification equipment, fans, and/or heaters inside enclosed areas to maintain the required atmospheric and surface temperature for proper coating application and cure at no additional cost to the Owner.

D. Concrete Substrate Temperatures and Detail Treatment:

1. When the surface temperatures of the concrete substrates to be coated are rising or when these substrates are in direct sunlight, outgassing of air from the concrete may result in bubbling, pinhole formations, and/or blistering in the coating system. The application of the filler/surface and the coating system will only be allowed during periods of falling temperature. This will require that application of the filler/surface and coating system only occur during the cooler evening hours. Include all cost for working outside of normal hours in the bid.
2. Repair all bubbles, fish eyes, pinholes, or other discontinuities that form in the applied coating system material as recommended by the CSM. Repair pinholes that develop in the filler/surfacer material or in the first coat of the coating material in accordance with the CSM's recommendations prior to application of the next coat of material. Open up and fill completely all air voids behind or beneath the pinhole with the specified filler/surfacer/coating material. Abrade the coated area around the pinhole repair and recoat that area.
3. Perform application detail work per CSM's current written recommendations and/or drawings.

E. Protection of Coated Surfaces:

1. Do not handle, work on, or otherwise disturb items that have been coated until the coating is completely dry and hard. Recoat or retouch shop-coated items after delivery at the site, and upon permanent erection or installation with specified coating when it is necessary to maintain the integrity of the film.

F. Method of Coating Application:
   1. Where 2 or more coats are required, provide sufficient compatible color additive, or contrasting color, in alternate coats to act as indicator of coverage, or the alternate coats shall be of contrasting colors. Do not use color additives containing lead or lead compounds which may be destroyed or affected by hydrogen sulfide or other corrosive gas, and/or chromium.
   2. Mechanical equipment, on which the equipment manufacturer's coating is acceptable, touch-up prime and coat with 2 coats of the specified coating system to match the color scheduled. Do not apply coatings to a surface until it has been prepared as specified. Apply the primer or first coat by brush to ferrous surfaces that are not blast cleaned. Coats for blast-cleaned ferrous surfaces and subsequent coats for non-blast cleaned ferrous surfaces may be either brush or spray applied. After the prime coat is dry, visually inspect all surfaces, and mark all visible pinholes and/or holidays, repair in accordance with CSM's recommendations, and reinspect visually before applying succeeding coats. Unless otherwise specified, brush, roll, or trowel coats for concrete and masonry.

G. Film Thickness and Continuity:
   1. Confirm WFT following application of each coat.
   2. Do not exceed the surface area covered per gallon of coating for various types of surfaces recommended by the CSM. The first coat, referred to as the prime coat, on metal surfaces refers to the first full paint coat and not to solvent wash, grease emulsifiers, or other pretreatment applications. Apply coatings to the thickness specified and in accordance with these specifications.
   3. Conduct visual observations of continuity of coating film quality at welds, projections (such as bolts and nuts), and crevices, to verify no holidays exist where the dry-mil thickness has been accepted. This continuity shall be the minimum required for these rough or irregular areas. Recoat pinholes and holidays to the required coverage.
   4. The ability to obtain specified film thickness is generally compromised when brush or roller application methods are used and, therefore, more coats may need to be applied to achieve the specified DFT.
   5. For concrete substrates, apply a complete skim coat of the specified filler/surfacer material over the entire substrate to produce a relatively flat continuous coatable surface prior to application of the coating system as required in the COATSPEC for the specific coating system. Apply the skim coat to the thickness recommended by the CSM and such that all open air voids and bugholes in the concrete substrate are completely filled prior to coating application.

H. Special Requirements:
   1. Before erection, apply all but the final finish coat to interior surfaces of roof plates, roof rafters and supports, pipe hangers, piping in contact with hangers, and contact surfaces that are inaccessible after assembly. Apply the final coat after erection. Coat structural friction connections and high tensile bolts and nuts after erection. Hand clean or power-tool clean areas damaged during erection and recoat with primer coat prior to the application of subsequent coats. Touch-up surfaces after installation. Confirm surfaces to be coated are clean and dry at the time of application.

2. Except for those to be filled with epoxy grout, coat the underside of equipment bases and supports that have not been galvanized with at least 2 coats of primer specified for system E-2 prior to setting the equipment in place. Provide coating system terminations at leading edges and transitions to other substrates in accordance with the CSM's recommendations or detail drawings.

I. Electrical and Instrumentation Equipment and Materials:

1. Electrical and instrumentation equipment and materials shall be shop coated by the equipment manufacturer in compliance with the standard (IEEE, ANSI, NEMA, etc.) referenced in the individual equipment specification. Before final acceptance, the Contractor shall touch up scratches on equipment with identical color coating. Finish shall be smooth, free of runs, and match existing finish. Prior to touching up scratches, Contractor shall fill them with an appropriate filler material approved by the CSM so evidence of prior scratches is not visible in the finish surface

3.04 CLEANUP

A. General:

1. Upon completion of coating, remove surplus materials, protective coverings, and accumulated rubbish, and thoroughly clean surfaces and repair overspray or other coating-related damage.

3.05 COATING SYSTEM SPECIFICATION SHEETS (COATSPEC)

A. General:

1. Coating systems for different types of surfaces and general service conditions for which these systems are normally applied are specified on the following COATSPEC sheets. Coat surfaces in accordance with the COATSPEC to the system thickness specified. Use coating systems as specified in paragraph 3.06. In case of conflict between the schedule and the COATSPECS, the requirements of the schedule take precedence.
2. Coating Specification Sheets included in Table A are included this paragraph 3.05.

Table A Coating Specification Sheets

Coating System ID	Coating Material	Surface	Service Condition
E-1	Epoxy	Metal	Interior; exterior, covered, not exposed to direct sunlight, non-corrosive exposure.
E-2	Epoxy	Metal	Exposed to high humidity, condensing conditions moderately corrosive vapors.
E-3	Epoxy	Concrete or masonry	Non-immersed, moderately corrosive vapor environment, color required.
E-4	Epoxy	Concrete, masonry, plaster, gypsum board	Interior of buildings.
ELA-1	Elastomeric Acrylic	Concrete or dense masonry block where existing crack or joint movement is suspected due to thermal conditions and would propagate through rigid epoxy coating systems and for exterior protection and aesthetics.	Exterior direct sunlight. Concrete or dense masonry block where existing crack or joint movement is suspected due to thermal conditions and would propagate through rigid epoxy coating systems and for exterior protection and aesthetics.

Table A Coating Specification Sheets

Coating System ID	Coating Material	Surface	Service Condition
EU-1	Zinc-epoxy-polyurethane system	Ferrous Metal	Exterior, exposed to direct sunlight, moderately corrosive non-immersed – vapor exposure.
EFL-1	Chemical Resistant Novolac Epoxy Flooring with Anti-Slip Broadcast	Concrete	Interior areas subjected to chemical splash and spill. (NOT SECONDARY CONTAINMENT).
EFL-2	Epoxy Flooring with Anti-Slip Broadcast	Concrete	Interior areas such as electrical Rooms, mechanical rooms, storage rooms, washrooms and other common Areas of foot or light cart traffic. Not subjected to chemical or UV exposure.
EFL-3	Epoxy Flooring with Anti-Slip and UV protective Topcoat	Concrete	Flooring with Exterior Exposure or other forms of UV exposure such as interior areas with lots of windows.
EU-1-FRP	Specialty Primer plus Polyurethane Finish Coat	Exterior of FRP pipe and tanks, etc.	Exterior, exposed to direct sunlight, non-immersed.
L-1	100% Acrylic Latex	Concrete, masonry, plaster, gypsum board	Interior including existing coated concrete.
L-2	100% Acrylic Latex	PVC and CPVC pipe	Exterior, direct sunlight exposure.
L-3	100% Acrylic- to Metal	Ferrous Metal	Interior or Exterior
S-1	Penetrating acrylic stain, color required	Concrete	Non-immersed, exposure to moisture and sunlight.
S-2	Silane or Siloxane or Blended Siloxane & Silane Sealer	Concrete Floors	Non-immersed, non-corrosive. Interior or exterior for waterproofing.
S-3	Silane or Siloxane or Blended Siloxane & Silane Sealer	Concrete or Masonry Walls	Exterior or Interior – Weathering Exposure, Non-Corrosive.

Coating System Specification Sheets (COATSPEC)

Coating System Identification: E-1

1. Coating Material:	Epoxy
2. Surface:	Metal
3. Service Condition:	Interior; exterior, covered, not exposed to direct sunlight, non-corrosive exposure.
4. Surface Preparation:	
a. General:	Shop primed surfaces which are to be incorporated in the work where recoat times have been exceeded shall be prepared in the field by cleaning surfaces by sanding to produce uniform profile of 0.5 to 1.0 mils and solvent cleaned per SSPC-SP 1. Damaged shop coated areas shall be cleaned in accordance with SSPC-SP6/NACE #3 Commercial Abrasive Blast Cleaning or SSPC-SP 11 to achieve a uniform surface profile of 2.0 to 2.5 mils in the metal substrate and spot primed with the primer specified. Shop epoxy primed surfaces shall require light abrasive sanding and vacuum cleaning prior to receiving finish coats.
b. Ferrous Metal:	Bare ferrous metal surfaces shall be prepared in accordance with SSPC-SP 6/NACE#3 (Commercial Blast Cleaning) to achieve a uniform, surface profile of 2.0 to 2.5 mils.
c. Nonferrous and Galvanized Metal:	Ferrous metal with rust bleeding shall be cleaned in accordance with SSPC-SP 1. Areas of rust penetration shall be spot blasted to SSPC-SP6/NACE#3 Commercial blast (to achieve the 2.0- to 2.5-mil surface profile) and spot

Coating System Specification Sheets (COATSPEC)	
	primed with the specified primer. For ductile iron surfaces, refer to the requirements in paragraph 3.02 Metallic Surfaces.
5. Application	Field
a. General:	Prime coat may be thinned and applied as recommended by the CSM, provided the coating as applied complies with prevailing air pollution control regulations.
b. Ferrous Metal:	Prime coats shall be an epoxy primer compatible with the specified finish coats and applied in accordance with the written instructions of the CSM.
c. Nonferrous and Galvanized Metal:	Nonferrous and galvanized metal shall be cleaned prior to the application of the prime coat in accordance with SSPC-SP 1 (Solvent Cleaning).
6. System Thickness:	10 mils dry film.
7. Coatings:	
a. Primer:	One coat at CSM's recommended DFT.
b. Finish:	One or more coats at CSM's recommended DFT per coat to achieve the specified system thickness.
Coating System Identification: E-2	
1. Coating Material:	Epoxy
2. Surface:	Metal
3. Service Condition:	Non-immersed, moderately corrosive environment, color required.
4. Surface Preparation:	
a. Ferrous Metal:	Ferrous metal surfaces shall be prepared in accordance with SSPC-SP 5 (White Metal Blast Cleaning) to achieve a uniform surface profile of 2.0 to 2.5 mils.
	Damaged shop coating shall be cleaned in accordance with SSPC-SP6/NACE #3 Commercial Blast Cleaning or SSPC-SP 11 and vacuum cleaning and spot primed with the primer specified. Shop epoxy primed surfaces shall require light abrasive blasting or abrading prior to receiving finish coats if the maximum recoat time for the primer has been exceeded. This cleaning must produce a uniform 1.0- to 1.5-mil profile in the intact shop primer. For ductile iron surfaces, refer to the requirements in paragraph 3.02 Metallic Surfaces.
b. Nonferrous and Galvanized Metal:	Nonferrous and galvanized metal shall be prepared in accordance with SSPC-SP 16 to achieve a uniform surface profile of 1.0 to 1.5 mils. Galvanized steel with this E-2 coating system shall not be used in routinely wet exposures.
5. Application:	Field
a. General:	Prime coat may be thinned and applied as recommended by the CSM, provided the coating as applied complies with prevailing air pollution control regulations.
b. Ferrous Metal:	Prime coat shall be an epoxy primer compatible with the specified finish coats.
c. Nonferrous and Galvanized Metal:	Nonferrous and galvanized metal, non-immersed, shall be coated prior to the application of the prime coat with a grease emulsifying agent in accordance with the CSM's written instructions. Nonferrous metal to be immersed shall not be painted. Galvanized metal shall not be immersed even if it is painted. If non-ferrous metals are not to be immersed, prepare in accordance with SSPC-SP 16.
6. System Thickness:	16 mils dry film.
7. Coatings:	
a. Primer:	One coat at CSM's recommended DFT.

Coating System Specification Sheets (COATSPEC)	
b. Finish:	Two or more coats at CSM's recommended DFT per coat to the specified system thickness.
Coating System Identification: E-3	
1. Coating Material:	Epoxy
2. Surface:	Concrete or masonry
3. Service Condition:	Non-immersed, moderately corrosive vapor environment, color required.
4. Surface Preparation:	
a. Concrete:	Concrete surfaces shall be allowed to cure for at least 28 days and allowed to dry to the moisture content recommended by the CSM before coating work proceeds. Moisture testing shall be performed in accordance with ASTM D4263, Moisture by Plastic Sheet Test. Any moisture on back of plastic sheet means coating application cannot proceed until the concrete or masonry has dried out. See section 3.02 for further testing requirements. Except as otherwise specified, loose concrete, form oils, surface hardeners, curing compounds, and laitance shall be removed from surfaces by abrasive blasting and chipping, and voids and cracks shall be repaired as specified in Section 03 30 00. Surface preparation can be performed by abrasive blast cleaning as per SSPC-SP 13/NACE #6 and SSPC SP CAB 1 or high pressure water jet cleaning and must achieve a uniform concrete surface profile of CSP 3 in accordance with ICRI 310.2. After cleaning, air voids or bugholes in the concrete shall be filled with a surfacer or block filler compatible with the specified primer and finish coats.
b. Masonry:	Masonry surfaces shall be allowed to cure for at least 28 days after being constructed and be allowed to dry to the moisture content recommended by the CSM. Holes or other joint defects shall be filled with a material compatible with the primers and finish coats or shall be filled with masonry mortar that shall cure for at least 28 days. Loose or splattered mortar shall be removed by scraping and chipping.
	Masonry surfaces shall be cleaned with clear water by washing and scrubbing to remove foreign, loose, and deleterious substances.
	Muriatic acid shall not be used. After cleaning, masonry surfaces shall be sealed or filled with a sealer or block filler compatible with the specified primer.
5. Application:	Field
a. General:	Apply filler/surfacer as recommended by CSM to fill bugholes and air voids or block texture, etc. leaving a uniformly filled surface that does not produce blowholes or outgassing causing pinholing of the coating system. Filler/surfacers shall dry a minimum of 48 hours prior to application of prime coat or as required by the CSM.
	Prime coat shall be thinned and applied as recommended by the CSM, provided the coating as applied complies with prevailing air pollution control regulations.
	Drying time between coats shall be as recommended by CSM.
6. System Thickness:	15 mils dry film.
7. Coatings:	
a. Primer:	One coat at CSM's recommended DFT.
b. Finish:	Two or more coats at CSM's recommended DFT per coat to the specified system thickness.
Coating System Identification: E-4	
1. Coating Material:	Epoxy
2. Surfaces:	Concrete, masonry, plaster, gypsum board

Coating System Specification Sheets (COATSPEC)	
3. Service Condition:	Interior
4. Surface Preparation:	
a. Concrete:	Concrete surfaces shall be allowed to age for at least 28 days and allowed to dry to the moisture content recommended by the CSM. Moisture content of gypsum and plaster surfaces may be tested with a Delmhorst Instrument Company moisture detector, or equal. Moisture levels of concrete and masonry shall be tested as per section 3.02. Moisture coated as recommended by the CSM must be met prior to coating application. Loose concrete, form oils, surface hardeners, curing compounds, and laitance shall be removed from surfaces, and voids and cracks shall be repaired as specified in Section 03 30 00. Surface preparation shall produce a concrete surface profile of CSP 2 in accordance with ICRI 310.2. After cleaning, air voids or bugholes in the concrete shall be filled with a surfacer or block filler compatible with the specified primer and finish coats.
b. Masonry:	Masonry surfaces shall be allowed to age for at least 28 days. Holes or other joint defects shall be filled with mortar and repointed. Loose or splattered mortar shall be removed by scraping and chipping. Masonry surfaces shall be cleaned with clear water by washing and scrubbing to remove foreign and deleterious substances. Muriatic acid shall not be used. After cleaning, exterior masonry surfaces shall be sealed or filled with a sealer or block filler compatible with the specified primer.
c. Plaster:	Plaster surfaces shall be dry, clean, and free from grit, loose plaster, and surface irregularities. Cracks and holes shall be repaired with acceptable patching materials, keyed to existing surfaces, and sandpapered smooth. Surfaces shall be cleaned with clean water by washing and scrubbing to remove foreign and deleterious substances.
5. Application:	Field
a. General:	Block Filler shall be multiple component epoxy block filler or an acrylic based or waterborne epoxy based block filler and shall dry a minimum of 48 hours prior to primer application or as required by the CSM.
	Prime coat shall be thinned and applied as recommended by CSM, provided the coating as applied complies with prevailing air pollution control regulations.
	Drying time between coats shall be as recommended by CSM.
6. System Thickness:	10 mils dry film, excluding block filler and sealer.
7. Coatings:	
a. Primer:	One coat at CSM's recommended DFT.
b. Finish:	One or more coats at CSM's recommended DFT per coat to the specified system thickness
Coating System Identification: ELA-1	
1. Coating Material:	Elastomeric Acrylic
2. Surface:	Concrete or Dense Masonry where existing crack or joint movement is suspected due to thermal conditions and would propagate through rigid epoxy coating systems and for exterior weathering protection, breathability and aesthetics.
3. Service Condition:	Interior or exterior, above grade, non-submerged direct sunlight – moderately corrosive due to vapor corrosion environment.

Coating System Specification Sheets (COATSPEC)	
4. Surface Preparation:	All coating termination and transition details shall be prepared in accordance with the CSM's standard detail drawings. This includes coating termination details, coating transitions at vertical and vertical to horizontal corners, coating terminations at joints, concrete crack treatment, coating terminations at metal embedments in the concrete substrate, and other details. The CSM's standard detail drawings shall be submitted for all such coating applications. If standard details are not available for a given detail treatment, the CSM shall be required to produce one at no additional cost to the Owner, the Engineer, or any other party.
	If wet abrasive or water jetting surface preparation methods were used, the concrete substrate shall be allowed to dry under warm conditions (minimum of 75 degrees F) for at least 5 days prior to coating application. Following surface preparation work and dry-out, all surfaces to be coated shall be vacuum cleaned to remove all loose dirt, dust, or other loose materials.
a. Concrete:	Concrete surfaces shall be allowed to cure for at least 28 days and allowed to dry to the moisture content recommended by the CSM. Moisture content shall be tested per ASTM D4263, Moisture by Plastic Sheet Test. Any moisture on back of plastic sheet means coating cannot proceed until the concrete or masonry has dried out. See section 3.02 for further testing requirements. Except as otherwise specified, loose concrete, form oils, surface hardeners, curing compounds, and laitance shall be removed from surfaces by Low Pressure Water Cleaning (LPWC with Pressures < 5000 psi) or by abrasive blasting and chipping as per SSPC-SP 13/NACE #6/SSPC-CAB #1-3. Voids and cracks shall be repaired as specified in Section 03 30 00. Surface Preparation may open up all shelled-over air voids or bugholes to expose fully the void's depth, width, and length. Filling materials may be required to provide the best aesthetic appeal. If abrasive blasting, the concrete shall be abraded to achieve a uniform minimum concrete surface profile of CSP 1-2 in accordance with ICRI 310.2.
5. Application:	Field
a. General:	Surfacer or fillers can be applied with these coating systems per CSM's recommendations prior to application of prime coat to fill bugholes and voids. These materials must be compatible with the primers and finish coats or preferably, a more textured version of this coating system can be selected to fill air voids (bugholes), etc. All cementitious products shall be applied to surfaces in an SSD condition.
	Prime coat shall be thinned and applied as recommended by the CSM, provided the coating as applied complies with prevailing air pollution control regulations.
6. System Thickness:	16 to 24 mils DFT
7. Coatings:	
a. Primer:	One coat at 3-5 mils DFT
b. Finish:	One or more coats at CSM's recommended DFT per coat to the specified system thickness
c. Testing:	Visual inspection shall be performed over 100 percent of the coated surface area to identify any holidays or pinholes that must be repaired.
d. Pinhole and Holiday Repair Procedure:	Pinholes or holidays identified by visual inspection shall be repaired per the CSM's recommendations.
Coating System Identification: EU-1	
1. Coating Material:	Zinc-Epoxy-Polyurethane System
2. Surface:	Ferrous Metal
3. Service Condition:	Exterior, exposed to direct sunlight, moderately corrosive, non-immersed.

Coating System Specification Sheets (COATSPEC)	
4. Surface Preparation:	
a. General:	Undamaged shop primed surfaces which have exceeded recoat times which are to be incorporated in the work shall be prepared in the field by sanding to produce a uniform surface profile followed by Solvent Cleaning per SSPC-SP 1. Damaged shop coated areas shall be cleaned in accordance with SSPC-SP 11 and recoated with the primer specified.
b. Ferrous Metal:	Bare ferrous metal surfaces shall be prepared in accordance with SSPC-SP 6 (Commercial Blast Cleaning) 2.0–2.5 mils. Ductile iron surfaces to be coated shall be abrasive blast cleaned in accordance with paragraph 3.02 Metallic Surfaces.
	Ferrous metal with rust bleeding shall be cleaned in accordance with SSPC-SP 11 (Power Tool Cleaning to Bare Metal). Areas of rust penetration shall be spot blasted to SSPC-SP 6/NACE #3 10 (Commercial Near White Blast Cleaning) and spot primed with the specified primer.
c. Galvanized Metal:	Damaged galvanized steel areas with exposed ferrous metal and/or rusted shall be cleaned in accordance with SSPC-SP 165 (White Metal Brush Off Abrasive Blast Cleaning for Galvanized and Non-Ferrous metal) or Power Tool Cleaned to Bare Metal in accordance with SSPC-SP 11 to achieve a uniform 1.0- to 1.5-mil profile. The zinc primer is NOT used on galvanized steel but is spot primed with the primer specified for galvanized metal as recommended by the CSM.
	Nonferrous and galvanized metal shall be prepared in accordance with SSPC-SP 16 (Brush Off Abrasive Blast Cleaning for Galvanized and Non-Ferrous metal) to impart a 1.0- to 2.0-mil profile to the galvanized or non-ferrous steel surfaces. Where this cannot be performed, prepare by abrading in accordance with SSPC-SP 113, Power Tool Cleaning to bare metal to impart a 1.0- to 1.5-mil profile uniformly to the galvanized steel surfaces.
	For EU-1 over galvanized steel, **DELETE the zinc rich primer**.
5. Application:	Field
a. General:	Prime coat may be thinned and applied as recommended by the CSM, provided the coating as applied complies with prevailing air pollution control regulations.
b. Ferrous Metal:	Prime coats shall be a zinc rich epoxy or polyurethane primer compatible for use with urethane finish coats and applied in accordance with written instructions of the CSM or in the case of CARB or SCAQMD applications, prime with specified primer that is not zinc rich. In these cases, only a 2-coat system is applied.
6. System Thickness:	3-4 mils of zinc rich primer, one intermediate or primer epoxy coat at 5-6 mils and one finish coat of polyurethane at 2-3 mils DFT.
7. Coatings:	
a. Primer:	One coat at CSM's recommended DFT
b. Intermediate:	One coat at CSM's recommended DFT
c. Finish:	One coat at CSM's recommended DFT per coat to meet the specified system thickness
Coating System Identification: EFL-1	
1. Coating Material:	100% Solids Chemical Resistant Novolac Epoxy with Anti-Slip Aggregate Broadcast
2. Surface	Concrete
3. Service Condition	Interior areas subject to chemical splash and spill (NOT SECONDARY CONTAINMENT)
4. Surface Preparation:	
a. General	All coating termination and transition details shall be prepared in accordance

Coating System Specification Sheets (COATSPEC)	
	with the CSM's standard detail drawings. This includes coating termination details, coating transitions at vertical and vertical to horizontal corners, coating terminations at joints, concrete crack treatment, coating terminations at metal embedment's in the concrete substrate, and other details. The CSM's standard detail drawings shall be submitted for all such coating applications. If standard details are not available for a given detail treatment, the CSM shall be required to produce one at no additional cost to the Owner, the Engineer, or any other party.
b. Concrete	Concrete surfaces shall be allowed to cure for at least 28 days and allowed to dry to the moisture content recommended by the CSM. Moisture content shall be tested per ASTM D4263, Moisture by Plastic Sheet Test. Any moisture on back of plastic sheet means coating cannot proceed until the concrete has dried out. See section 3.02 for further testing requirements. Except as otherwise specified, loose concrete, form oils, surface hardeners, curing compounds, and laitance shall be removed from surfaces. Prepare all surfaces by shot blasting as per SSPC SP-13/NACE#6 M-SB. Filling materials may be required to provide the best aesthetic appeal. If abrasive blasting, the concrete shall be abraded to achieve a uniform minimum concrete surface profile of CSP 3 in accordance with ICRI 310.2. unless otherwise directed by the CSM.
5. Application	Field
a. General	Surfacers, fillers or leveling/sloping materials can be applied with these coating systems per CSM's recommendations prior to application of prime coat to fill voids, holes or to appropriately slope or level the floors. These materials must be compatible with primers and finish coats. All cementitious products shall be applied to surfaces in an SSD condition.
	All materials shall be applied as per the strict instructions of the CSM.
6. System Thickness	26-40 mils (Varies Depending on CSM) The various CSM's have different approaches and film thickness requirements for the system. The CSA shall consult the CSM for total film thickness requirements
7. Coatings	
a. Primer	One Coat at 8-10 mils
b. Body Coat	One Coat at 12-15 mils with 20/40 mesh Anti-Slip Aggregate Broadcast into the wet coating at sufficient volume to provide the desired anti-slip profile through the topcoat. A mockup of the level of anti-slip must be performed to ensure the level of anti-slip is acceptable to the owner. Overly aggressive anti-slip aggregate can make cleaning the floor difficult. When the anti-slip aggregate is added by broadcast the CSA shall backroll the material to ensure encapsulation of the aggregate into the material. The Tnemec system uses 50/70 mesh aggregate rather than the 20/40 mesh aggregate used by PPG and Sherwin Williams.
c. Finish	6-15 mils (Varies Depending on CSM) The various CSM's have different approaches and film thickness requirements for the topcoat. The CSA shall consult the CSM for topcoat film thickness requirements.
8. Testing	Visual inspection shall be performed over 100 percent of the coated surface area to identify any holidays or pinholes that must be repaired. Visual inspection to ensure proper application and film quality and level of acceptable anti-slip agreed upon in the mockup.
9. Pinhole and Holiday Repair Procedure:	Pinholes, holidays and other film defects identified by visual inspection shall be repaired per the CSM's recommendations.
Coating System Identification: EFL-2	
1. Coating Material	100% Solids Epoxy Floor Coating
2. Surface	Concrete

Coating System Specification Sheets (COATSPEC)	
3. Service Conditions	Interior Floors in Common Areas not subjected to chemical exposure or UV.
4. Surface Preparation	
a. General	All coating termination and transition details shall be prepared in accordance with the CSM's standard detail drawings. This includes coating termination details, coating transitions at vertical and vertical to horizontal corners, coating terminations at joints, concrete crack treatment, coating terminations at metal embedment's in the concrete substrate, and other details. The CSM's standard detail drawings shall be submitted for all such coating applications. If standard details are not available for a given detail treatment, the CSM shall be required to produce one at no additional cost to the Owner, the Engineer, or any other party.
b. Concrete	Concrete surfaces shall be allowed to cure for at least 28 days and allowed to dry to the moisture content recommended by the CSM. Moisture content shall be tested per ASTM D4263, Moisture by Plastic Sheet Test. Any moisture on back of plastic sheet means coating cannot proceed until the concrete has dried out. See section 3.02 for further testing requirements. Except as otherwise specified, loose concrete, form oils, surface hardeners, curing compounds, and laitance shall be removed from surfaces. Prepare all surfaces by shot blasting as per SSPC SP-13/NACE#6 M-SB. Filling materials may be required to provide the best aesthetic appeal. If abrasive blasting, the concrete shall be abraded to achieve a uniform minimum concrete surface profile of CSP 3 in accordance with ICRI 310.2. unless otherwise directed by the CSM.
5. Application	Field
a. General	Surfacers, fillers or leveling/sloping materials can be applied with these coating systems per CSM's recommendations prior to application of prime coat to fill voids, holes or to appropriately slope or level the floors. These materials must be compatible with primers and finish coats. All cementitious products shall be applied to surfaces in an SSD condition.
	All materials shall be applied as per the strict instructions of the CSM.
6. System Thickness	26-40 mils (Varies Depending on CSM) The various CSM's have different approaches and film thickness requirements for the system. The CSA shall consult the CSM for total film thickness requirements
7. Coatings	
a. Primer	One Coat at 8-10 mils
b. Body Coat	One Coat at 12-15 mils with 20/40 mesh Anti-Slip Aggregate Broadcast into the wet coating at sufficient volume to provide the desired anti-slip profile through the topcoat. A mockup of the level of anti-slip must be performed to ensure the level of anti-slip is acceptable to the owner. Overly aggressive anti-slip aggregate can make cleaning the floor difficult. When the anti-slip aggregate is added by broadcast the CSA shall backroll the material to ensure encapsulation of the aggregate into the material. The Tnemec system uses 50/70 mesh aggregate rather than the 20/40 mesh aggregate used by PPG and Sherwin Williams.
c. Finish	One Coat at 6-15 mils (Varies Depending on CSM) The various CSM's have different approaches and film thickness requirements for the topcoat. The CSA shall consult the CSM for topcoat film thickness requirements.
8. Testing	Visual inspection shall be performed over 100 percent of the coated surface area to identify any holidays or pinholes that must be repaired. Visual inspection to ensure proper application and film quality and level of acceptable anti-slip agreed upon in the mockup.

Coating System Specification Sheets (COATSPEC)	
9. Pinhole and Holiday Repair Procedure.	Pinholes, holidays and other film defects identified by visual inspection shall be repaired per the CSM's recommendations.
Coating System Identification: EFL-3	
1. Coating Material	100% Solids Epoxy Floor Coating /UV Resistant Polyurethane/Polyaspartic
2. Surface	Concrete
3. Service Condition	Exterior concrete floor surfaces subjected to UV but not subjected to chemical exposure, or interior concrete floor surfaces with UV exposure
4. Surface Preparation	
a. General	All coating termination and transition details shall be prepared in accordance with the CSM's standard detail drawings. This includes coating termination details, coating transitions at vertical and vertical to horizontal corners, coating terminations at joints, concrete crack treatment, coating terminations at metal embedment's in the concrete substrate, and other details. The CSM's standard detail drawings shall be submitted for all such coating applications. If standard details are not available for a given detail treatment, the CSM shall be required to produce one at no additional cost to the Owner, the Engineer, or any other party.
b. Concrete	Concrete surfaces shall be allowed to cure for at least 28 days and allowed to dry to the moisture content recommended by the CSM. Moisture content shall be tested per ASTM D4263, Moisture by Plastic Sheet Test. Any moisture on back of plastic sheet means coating cannot proceed until the concrete has dried out. See section 3.02 for further testing requirements. Except as otherwise specified, loose concrete, form oils, surface hardeners, curing compounds, and laitance shall be removed from surfaces. Prepare all surfaces by shot blasting as per SSPC SP-13/NACE#6 M-SB. Filling materials may be required to provide the best aesthetic appeal. If abrasive blasting, the concrete shall be abraded to achieve a uniform minimum concrete surface profile of CSP 3 in accordance with ICRI 310.2. unless otherwise directed by the CSM.
5. Application	Field
a. General	Surfacers, fillers or leveling/sloping materials can be applied with these coating systems per CSM's recommendations prior to application of prime coat to fill voids, holes or to appropriately slope or level the floors. These materials must be compatible with primers and finish coats. All cementitious products shall be applied to surfaces in an SSD condition.
	All materials shall be applied as per the strict instructions of the CSM.
6. System Thickness	26-52 mils (Varies Depending on CSM) The various CSM's have different approaches and film thickness requirements for the system. The CSA shall consult the CSM for total film thickness requirements
7. Coatings	
a. Primer	One Coat at 8-10 mils
b. Body Coat	One Coat at 12-15 mils with 20/40 mesh Anti-Slip Aggregate Broadcast into the wet coating at sufficient volume to provide the desired anti-slip profile through the topcoat. A mockup of the level of anti-slip must be performed to ensure the level of anti-slip is acceptable to the owner. Overly aggressive anti-slip aggregate can make cleaning the floor difficult. When the anti-slip aggregate is added by broadcast the CSA shall backroll the material to ensure encapsulation of the aggregate into the material. The Tnemec system uses 50/70 mesh aggregate rather than the 20/40 mesh aggregate used by PPG and Sherwin Williams.
c. Finish	One Coat at 2 - 9.6 mils (Varies Depending on CSM) The various CSM's have different approaches and film thickness requirements for the topcoat. The CSA shall consult the CSM for topcoat film thickness requirements.

Coating System Specification Sheets (COATSPEC)	
8. Testing	Visual inspection shall be performed over 100 percent of the coated surface area to identify any holidays or pinholes that must be repaired. Visual inspection to ensure proper application and film quality and level of acceptable anti-slip agreed upon in the mockup.
9. Pinhole and Holiday Repair Procedure	Pinholes, holidays and other film defects identified by visual inspection shall be repaired per the CSM's recommendations.
Coating System Identification: EU-1-FRP	
1. Coating Material:	Epoxy Primer plus Polyurethane Finish Coat.
2. Surface:	Exterior of FRP Pipe and Tanks, etc.
3. Service Condition:	Exterior, exposed to direct sunlight, non-immersed.
4. Surface Preparation:	
a. General:	Clean to remove loose dirt, dust, or other contaminants.
	Prepare surfaces by sanding to produce roughness to achieve a uniform, minimum surface profile of 1.5 to 2.0 mils. Abrasive Sweep blasting can also be used providing care is taken not to over blast.
	Solvent clean thoroughly using solvent as recommended by the CSM.
	Thoroughly clean to remove loose debris by vacuum cleaning.
5. Application:	Field
a. General:	Apply primer coat and thin as recommended by the CSM provided the coating applied complies with prevailing air pollution control regulations.
	Apply finish coat as recommended by the CSM.
6. System Thickness:	Primer to 2-4 mils and finish coat is 2-3 mils DFT.
7. Coatings:	
a. Primer:	One coat at CSM's recommended DFT.
b. Finish:	One coat at CSM's recommended DFT per coat to meet the specified system thickness.
Coating System Identification: L-1	
1. Coating Material:	100 percent Acrylic Latex.
2. Surfaces:	Concrete, masonry, plaster, gypsum board.
3. Service Condition:	Interior including existing coated concrete.
4. Surface Preparation:	
a. Concrete:	Concrete surfaces shall be allowed to age for at least 28 days and allowed to dry to the moisture content recommended by the CSM. Moisture content of gypsum and plaster surfaces shall be tested with a Delmhorst Instrument Company moisture detector, or equal. Moisture levels of concrete and masonry shall be tested as per ASTM D4263, Plastic Sheet Method and section 3.02. Moisture content must meet CSM's recommendation for coating work to proceed. Loose concrete and laitance shall be removed from surfaces, and voids and cracks shall be repaired as specified in Section 03 30 00.
b. Existing Coated Concrete:	Remove all loose coating down to a sound substrate or intact, well-adhered existing coating by scraping or other means. Then, abrade all surfaces to achieve a 0.5 to 1.5-mil uniform profile and vacuum clean to remove all loose dirt, paint chips, and dirt.
c. Masonry:	Masonry surfaces shall be allowed to age for at least 28 days. Holes or other joint defects shall be filled with mortar and repointed. Loose or splattered mortar shall be removed by scraping and chipping. Masonry surfaces shall be cleaned with clear water by washing and scrubbing to remove foreign and deleterious substances. Muriatic acid shall not be used. After cleaning,

	masonry surfaces shall be filled with block filler compatible with the specified primer.
d. Plaster:	Plaster surfaces shall be dry, clean, and free from grit, loose plaster, and surface irregularities. Cracks and holes shall be repaired with acceptable patching materials, keyed to existing surfaces, and sandpapered smooth. Surfaces shall be cleaned with clear water by washing and scrubbing to remove foreign and deleterious substances. After cleaning, surfaces shall be sealed with a compatible sealer.
e. Gypsum Wallboard:	Tape joints and spackled nail heads shall be sanded smooth and dusted. Seal with PVA sealer for interior uses only.
5. Application:	Field
a. General:	Sealer or filler shall dry a minimum of 48 hours prior to primer application.
	Drying time between coats shall be as recommended by CSM.
6. System Thickness:	4 mils dry film.
7. Coatings:	
a. Primer:	One coat at CSM's recommended DFT.
b. Finish:	Two or more coats at CSM's recommended DFT per coat to the specified system thickness.
Coating System Identification: L-2	
1. Coating Material:	100 percent Acrylic Latex.
2. Surface:	PVC and CPVC pipe.
3. Service Condition:	Interior and Exterior non-corrosive to mildly corrosive atmospheres suitable for direct sunlight exposure.
4. Surface Preparation:	Plastic pipe shall be cleaned with solvent compatible with the specified primer and sanded to roughen surfaces to achieve a uniform surface profile of 1.0 to 1.5 mils. Vacuum clean or wipe with a damp rag after sanding to remove all loose dust, plastic particles, and dirt.
5. Application:	Field
6. System Thickness:	3 mils dry film.
7. Coatings:	
a. Primer:	One coat at CSM's recommended DFT.
b. Finish:	One or more coats at CSM's recommended DFT per coat to the specified system thickness.
Coating System Identification: L-3	
1. Coating Material:	100 percent Acrylic – Direct to Metal or with a Primer.
2. Surface:	Ferrous Metal, Galvanized Metal and Non-Ferrous Metals.
3. Service Condition:	Interior or Exterior
4. Surface Preparation:	
a. Ferrous Metals:	Bare ferrous metal surfaces shall be prepared in accordance with SSPC-SP 6/NACE #3 (Commercial Blast Cleaning) unless specified otherwise. Impart a 1.5- to 2.0-mil profile to substrate.
	Ferrous metal with rust bleeding shall be cleaned in accordance with SSPC-SP 1 (Solvent Cleaning). Areas of rust penetration shall be spot blasted to SSPC-SP 10/NACE #2 (Near White Blast) and spot primed with the specified primer.
	Shop primed surfaces which are to be incorporated in the work shall be prepared in the field by cleaning surfaces in accordance with SSPC-SP 2 (Hand Tool Cleaning) or SSPC-SP 3 (Power Tool Cleaning).

Coating System Specification Sheets (COATSPEC)	
b. Nonferrous and Galvanized Metal:	Galvanized or nonferrous surfaces shall be prepared in accordance with SSPC-SP 1 (Solvent Cleaning) for doors and frames and other general usage or SSPC-SP 16 in areas where a more robust surface preparation is required. Solvent clean as per SSPC-SP 1 or vacuum clean after Brush Blast Cleaning in accordance with SSPC-SP 16.
5. Application:	Field
6. System Thickness:	4 to 6 mils dry film.
7. Coatings:	
a. Primer:	One coat at CSM's recommended DFT.
b. Finish:	Two or more coats at CSM's recommended DFT per coat to the specified system thickness.
Coating System Identification: S-1	
1. Coating Material:	Penetrating acrylic stain, color required.
2. Surface:	Concrete
3. Service Condition:	Non-immersed, exposure to moisture and sunlight.
4. Surface Preparation:	Low pressure water cleaning (LPWC at pressures <5000 psi or industry standard acid etch or other preparation as approved by the CSM).
5. Application:	
a. General:	Drying time between coats shall be as specified by the CSM for the site conditions.
b. Coatings:	Minimum of two coats overall (coat as many times as required to achieve desired color).
6. System Thickness:	200 square feet per gallon maximum or as recommended by the CSM
7. Color Selection:	As approved by the Owner.
Coating System Identification: S-2	
1. Coating Material:	Penetrating Water Repellent (Clear and Non-Film Building).
2. Surface:	Concrete Floors
3. Service Condition:	Exterior and Interior
4. Surface Preparation:	Clean surfaces of all traces of dirt, dust, efflorescence, mold, salt, grease, oil, asphalt, laitance, curing compounds, paint, coatings, and other foreign materials by low pressure water cleaning (LPWC at pressures <5000 psi) and/or chemical cleaners or other preparation as approved by the CSM.
a. Concrete	Concrete surfaces shall be allowed to age for at least 28 days and allowed to dry to the moisture content recommended by the CSM. Moisture content shall be tested with a Delmhorst Instrument Company moisture detector or equal. Acceptable content for coating application to be recommended by CSM. Loose concrete and laitance shall be removed from surfaces, and voids and cracks shall be repaired as specified in Section 03 30 00.
5. Application:	
a. General:	As per CSM’s instructions. Drying time before placing into service shall be as recommended by the CSM for site conditions.
6. System Coverage:	Follow CSM’s recommendations.
7. Color Selection:	Clear
Coating System Identification: S-3	
1. Coating Material:	Penetrating Water Repellent (Clear & Non-Film Building).
2. Surface:	Concrete and Masonry Walls
3. Service Condition:	Exterior and Interior

Coating System Specification Sheets (COATSPEC)	
4. Surface Preparation:	Clean surfaces of all traces of dirt, dust, efflorescence, mold, salt, grease, oil, asphalt, laitance, curing compounds, paint, coatings, and other foreign materials by brush-off blast, low pressure water cleaning (LPWC at pressures <5000 psi) and/or chemical cleaners or other preparation as approved by the CSM.
a. Concrete	Concrete surfaces shall be allowed to age for at least 28 days and allowed to dry to the moisture content recommended by the CSM. Moisture content shall be tested with a Delmhorst Instrument Company moisture detector or equal. Acceptable moisture content to be as recommended by the CSM. Loose concrete and laitance shall be removed from surfaces, and voids and cracks shall be repaired as specified in Section 03 30 00.
b. Masonry:	Masonry surfaces shall be allowed to age for at least 28 days. Holes or other joint defects shall be filled with mortar and repointed. Loose or splattered mortar shall be removed by scraping and chipping. Masonry surfaces shall be cleaned with clear water by washing and scrubbing to remove foreign and deleterious substances. Muriatic acid shall not be used.
5. Application:	
a. General:	Drying time before placing into service shall be as recommended by the CSM for site conditions.
6. System Coverage:	Follow CSM's recommendations.
7. Color Selection:	Clear

3.06 COATING SYSTEMS SCHEDULE (FINISH SCHEDULE)

A. General:

1. Specific coating systems, colors, and finishes for rooms, galleries, piping, equipment, and other items that are coated are specified in the following coating system schedule. Unless otherwise specified in the coating system schedule, the word "interior" shall mean the inside of a building or structure, and the word "exterior" shall mean outside exposure to weather elements.

Coating Systems Schedule (Finish Schedule)		
Location/Surface	**Coating System Identification**	**Standard Color**
General: All Surfaces not Specified by Area or Structure		
1. Structural Steel and Metal Decking	E-2 or EU-1	Note 2
2. Galvanized metal	Uncoated unless noted otherwise	
3. Stainless steel	Uncoated unless noted otherwise	
4. Equipment and Metal Appurtenances		
a. Equipment, non-immersed, unless otherwise specified		
1) Interior	E-1	Note 2
2) Exterior	EU-1	Note 2
b. Existing equipment		
1) Not damaged nor modified by work in this contract	Uncoated	–
2) Damaged, exposed, or modified by work in this contract		Note 3
a) Interior	E-1	Note 3, Match existing color
b) Exterior	EU-1 without primer	Note 3, Match existing color

Coating Systems Schedule (Finish Schedule)

Location/Surface	Coating System Identification	Standard Color
c. Electrical switchgear panels, unit substations, motor control centers, power transformers, distribution centers, and relay panels; interior and exterior	See paragraph 3.03 Electrical and Instrumentation Equipment and Materials	ANSI 61 Grey (outside) FS 27880 White (inside)
d. Instrumentation panels, graphic indicating panels, indicating and transmitting field panels, unless otherwise specified		
1) Interior		FS 26306 Grey (outside) FS 27880 White (inside)
2) Exterior		FS 27722 White (outside) FS 27880 White (inside)
e. Existing electrical and instrumentation panels		
1) Not damaged by work in this contract	Uncoated	–
2) Damaged or exposed to outside surfaces by work in this contract		
a) Interior	E-1	FS 26306 Grey
b) Exterior	EU-1 without primer	FS 26306 Grey (Electrical) FS 27722 White (Instrumentation)
5. Conduit, Piping and Ductwork		
a. Ferrous, non-ferrous and galvanized piping, and appurtenant hangers and supports, non-immersed, unless otherwise specified.		
1) Interior – noncorrosive	E-1	FS 26306 Grey
2) Exterior – noncorrosive	EU-1	FS 26306 Grey
3)		
b. Ferrous piping, appurtenant and supports, non-immersed	E-2	To be determined
c. Conduit, outlet and junction boxes, lighting transformers, lighting, communication and small power panels, control stations, piping, lagged ductwork, appurtenant hangers, clamps, and supports on coated surfaces, unless otherwise specified.		
1) Interior	E-1	Match background color
2) Exterior	EU-1	Match background color
d. Conduit, outlets and junction boxes, lighting transformers, lighting, communication and small power panels, control stations, piping, lagged ductwork, appurtenant hangers, clamps and supports on uncoated surfaces, unless otherwise specified		
1) Interior	E-1	FS 26306 Grey
2) Exterior	EU-1	FS 26306 Grey

Coating Systems Schedule (Finish Schedule)

Location/Surface	Coating System Identification	Standard Color
e. Existing conduit, outlet and junction boxes, lighting transformers, lighting communication and small power panels, control stations, piping, lagged ductwork, appurtenant hangers, clamps, and supports		
1) Not damaged nor modified by work in this contract	Uncoated	–
2) Damaged, exposed, or modified by work in this contract		
a) Interior	E-1	Match existing color
b) Exterior	EU-1	Match existing color
f. Racked conduits and cable trays	Uncoated	–
g. Insulated pipe jacketing	Uncoated	–
h. Plastic, fiberglass and flexible conduit and piping		
1) Unless otherwise specified	Uncoated	–
2) PVC and CPVC Piping	L-2	FS 26306 Grey
a) Exposed to direct sunlight	L-2	FS 26306 Grey
b) Not exposed to direct sunlight	L-2	FS 26306 Grey
i. Exposed ductwork, unless otherwise specified	Uncoated	–
6. Concrete, Grout, Masonry and Plaster		
a. Immersed tank and channel walls and bottoms unless otherwise specified.	Uncoated	–
b. Outside concrete walls below grade common with dry area or room	–	–
c. Walls and ceilings		
1) Precast concrete or colored masonry	Uncoated	–
2) Exterior, unless otherwise specified	Uncoated	–
3) Interior, unless otherwise specified	E-4	Note 2
d. Concrete equipment bases unless otherwise specified	E-4	Match equipment color
e. Floors unless otherwise specified	S-2	Note 2
f. Existing coated surfaces.	L-1	Match existing color
7. Door and Door Frames		
a. Doors unless otherwise specified		
1) Ferrous metal		
a) Interior	E-1	Note 2
b) Exterior	EU-1	Note 2
2) Aluminum	Uncoated	–
3) Other	Plastic laminate	Formica 947 Brown
4) Existing		
a) Not damaged by work in this contract	Uncoated	–
b) Damaged, exposed, or modified by work in this contract		
(1) Interior	E-1 (see paragraph 3.02 Masonry Surfaces)	Match existing color

Coating Systems Schedule (Finish Schedule)

Location/Surface	Coating System Identification	Standard Color
(2) Exterior	EU-1	Match existing color
b. Door frames unless otherwise specified		
1) Adjacent wall coated		
a) Interior	E-1	Match wall color
b) Exterior	EU-1	Match wall color
2) Adjacent wall uncoated		
a) Interior	E-1	Note 2
b) Exterior	EU-1	Note 2
3) Aluminum	Uncoated	–
4) Existing		
a) Not damaged by work in this contract	Uncoated	–
b) Damaged, exposed, or modified by work in this contract		
(1) Interior	E-1	Match existing color
(2) Exterior	EU-1 without primer	Match existing color
8. Handrails, Gratings, Floor Plates, Manhole Covers, and Hatches		
a. Unless otherwise specified	Uncoated	
b. Existing		
1) Not damaged by work in this contract	Uncoated	–
2) Damaged, exposed, or modified by work in this contract		
a) Interior	E-1	Match existing color
b) Exterior	EU-1 without primer	Match existing color
9. Metal Stairs, Ladders, Platforms, and Supports Except Tread and Grating		
a. Interior	E-1	Note 2
b. Exterior	EU-1	Note 2
c. Existing		
1) Not damaged nor modified by work in this contract	Uncoated	–
2) Damaged, exposed, or modified by work in this contract		
a) Interior	E-1	Match existing color
b) Exterior	EU-1 without primer	Match existing color
10. Aluminum Flashing, Light Standards, Supports, and Louvers		
a. Interior and exterior, unless otherwise specified	Uncoated	–
11. Precast Concrete Metalwork		
a. Fasteners, anchors, supports, etc.	EU-1	Match wall
12. Other		

Coating Systems Schedule (Finish Schedule)

Location/Surface	Coating System Identification	Standard Color
a. Pipe, ductwork, equipment and appurtenances made from fiberglass, plastic, rubber, including flexible hose, conduit, and plastic coated tubing, in areas not exposed to view (interior) (metal hangers and supports are coated with E-1)	Uncoated	–

Notes:

1. *Owner will select color from coating manufacturer's list of EPA approved colors for potable water.*
2. *Owner to select color from coating manufacturer's full range of standard colors.*
3. *Recoat existing equipment to provide a uniform appearance. Color shall remain the same unless otherwise noted in the Contract Documents.*

3.07 QUALITY ASSURANCE INSPECTION

A. General:

1. Inspection by the Owner or others does not limit the Contractor's or CSA's responsibilities for quality workmanship or sole responsibility for QC as specified by this Section or as required by the CSM's instructions. Inspection by the Owner is optional and is additional to any inspection required to be performed by the Contractor.
2. The Owner may perform, or contract with an inspection agency to perform, QA inspection and testing of the coating work covered by this Section. These inspections may include the following:
   a. Inspect materials upon receipt to ensure that all are supplied by the same CSM.
   b. Inspect to verify that specified storage conditions for the coating system materials, solvents, and abrasives are provided.
   c. Inspect and record findings for the degree of cleanliness of substrates.
   d. Inspect and record the pH of concrete and metal substrates.
   e. Inspect and record substrate profile (anchor pattern).
   f. Measure and record ambient air and substrate temperature.
   g. Measure and record relative humidity.
   h. Check for the presence of substrate moisture in the concrete.
   i. Inspect to verify that correct mixing of coating system materials is performed in accordance with CSM's instructions.
   j. Inspect, confirm, and record that the "pot life" of coating system materials is not exceeded during installation. Inspect to verify that recoat limitations for coating materials are not exceeded.
   k. Perform adhesion testing.
   l. Measure and record the thickness of the coating system.
   m. Inspect to verify proper curing of the coating system in accordance with the CSM's instructions.
   n. Limited visual observations for defects.

3.08 FINAL INSPECTION

A. General

1. Contractor shall conduct a final inspection to determine whether coating system work meets the requirements of the specifications.
2. The Construction Manager or Owner's Representative will subsequently conduct a final observation with the Contractor to observe the completed work.
3. Any obvious defects or non-conforming work shall be marked. Such areas shall be recleaned and repaired as specified at no additional cost to the Owner.

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PART 4 PROJECT QUALITY CONTROL CHECKLIST

09 90 00-A COATING SYSTEM QUALITY CONTROL CHECKLIST

Project Name

Owner		**Coating System Manufacturer Technical CTR**	
General Contractor (GC)		**Coating System Applicator (CSA)**	
Area or Structure		**Location within Structure**	
Coating System (e.g., E-1)		**Coating Type (e.g., Epoxy, etc.)**	

Coating System Quality Control Checklist

Step	Description	Acceptance Criteria	Parties	Name	Signature	Date
1	Completion of cleaning and substrate decontamination prior to abrasive blast cleaning.	Visual Inspection- Contaminant Free	GC QC			
		ASTM F22 – Concrete-Contaminant Free	CTR QC			
		Blacklight Testing- Contaminant Free	CSA QC			
2	Installation of protective enclosure of structure or area and protection of adjacent surfaces or structures that are not to be coated.	As Per SSPC Guide 6	GC QC			
		As per Specification	CTR QC			
			CSA QC			
3	Ambient condition control in structure or building area and acceptance of ventilation methods in structure or Area.	Negative Pressure in Enclosures	GC QC			
		Testing Every 2 hrs Minimum	CTR QC			
		Substrate temp 5°above the dewpoint and stabilized.	CSA QC			
4	Ensuring compressed air for abrasive blasting or coating/lining application is free of oil and moisture	ASTM D4285- Free of all oil & moisture	GC QC			
		1 blotter test per 2 hrs of compressed air usage	CTR QC			
			CSA QC			
5	Completion of Surface Preparation for Substrates to Be Coated. (Steel & Concrete)	Compliance with Sited SSPC/NACE Standards	GC QC			
		Compliance with Specification	CTR QC			
			CSA QC			

Step	Description	Acceptance Criteria	Parties	Name	Signature	Date
6	Steel- Dust Level Testing- After surface preparation and prior to application of primers/coatings	ISO 8502-3 (Part 3)	GC QC			
		Dust Rating-1	CTR QC			
		Dust Particle Size - 0	CSA QC			
7	Soluble Chloride Testing (If needed) as per SSPC-Guide 15 (Steel Only)	AS Per CTR allowable limits per product.	GC QC			
			CTR QC			
			CSA QC			
8	Completion of Concrete Repairs If Required and Related Surface Preparation Rework Prior to Coating System Application.	Compliance with Specification	GC QC			
			CTR QC			
			CSA QC			
9	Completion of Concrete Filler/ Surface Application to Concrete.	Bughole/Void Free	GC QC			
		Flush with Existing Surface	CTR QC			
			CSA QC			
10	Completion of Primer Application.	SSPC-PA 2- Steel	GC QC			
		SSPC-PA 9- Concrete	CTR QC			
		Meets Specified DFT	CSA QC			
11	Completion of intermediate Coat Application and of Detail Treatment at Transitions or Terminations.	SSPC-PA 2- Steel	GC QC			
		SSPC-PA 9- Concrete	CTR QC			
		Meets Specified DFT	CSA QC			
12	Completion of Finish Coat Application and of Detail Treatment at Transitions and Terminations.	SSPC-PA 2- Steel	GC QC			
		SSPC-PA 9- Concrete	CTR QC			
		Meets Specified DFT	CSA QC			
13	Completion of Full and Proper Cure of Coating System.	ASTM D5402- Solvent Based Materials - No material transfer-	GC QC			
		Visual Inspection-Defect Free	CTR QC			
			CSA QC			
14	Completion of Testing of Cured Coating System including Adhesion, Holiday (Continuity) Testing and Dry Film Thickness.	ASTM D5402- Solvent Based Materials - No material transfer-	GC QC			
		Visual Inspection-Defect Free	CTR QC			
		As per Specification	CSA QC			

Step	Description	Acceptance Criteria	Parties	Name	Signature	Date
15	Completion of Localized Repairs to Coating System Following Testing.	Visual Inspection-Defect Free	GC QC			
			CTR QC			
			CSA QC			
16	Final Acceptance of Coating System Installation Including Final Clean-Up Complying with Specification Requirements and the CTR's Quality Requirements.	Visual Inspection-Defect Free	GC QC			
			CTR QC			
			CSA QC			

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SECTION 23 00 00

HEATING, VENTILATING, AND AIR CONDITIONING (HVAC) BASIC REQUIREMENTS

PART 1 GENERAL

1.01 SUMMARY

A. Scope: This Section specifies the general requirements for all of the HVAC materials, labor, tools, permits, incidentals, and other services included in Division 23 and elsewhere wherever specifically mentioned in the Specifications.
   1. Piping, pipe supports, valves, and accessories which are not an integral part of the equipment or are not specified herein are covered in other sections.
   2. Ductwork and Accessories shall be per Sections 23 31 13 and 23 31 16.

B. Environmental Conditions: See Section: 01 11 80

C. Fasteners: unless indicated otherwise.
   1. Bolts - ASTM A193, grade B8M Class 1 or ASTM A320 B8M Class 1
   2. Nuts – ASTM A194, grade 8M
   3. Washer – 316 SS

D. Governing Standards:
   1. Except as modified or supplemented herein, all work covered by this section shall be performed in accordance with all applicable municipal codes and ordinances, laws, and regulations. In case of a conflict between this section and any state law or local ordinance the more stringent requirements shall govern.
   2. All work shall comply with UL safety requirements.

E. Suitable connections shall be provided for each fixture, piece of equipment, and appurtenance.

F. Coordinate with other trades (e.g., Plumbing, Fire Protection, Structural) for routing of equipment and connection points

G. Power Supply:
   1. Power supply to equipment with motors shall be as indicated by manufacturer. Power supply for controls shall be 120 volts, 60 Hz, single phase unless otherwise required for a properly operating system.

H. Metal Thickness:
   1. Metal thickness and gages specified herein are minimum requirements. Gages refer to US Standard gage.

1.02 DEFINITIONS

A. Terminology used in this specification conforms to the following definitions:
   1. Authorities Having Jurisdiction: Indicates reviewing authorities, including local building official, local fire marshal, Owner, and other reviewing entity whose approval is required to obtain system acceptance.

2. ACH: Air changes per hour.
3. SCFM: Standard cubic feet per minute.
4. ACFM: Actual cubic feet per minute
5. Ft^2: Square foot.
6. TAB: Testing and Balancing.

1.03 SUBMITTALS

A. The following information shall be provided in accordance with Section 01 33 00.
   1. A copy of this specification section, with addendum updates included, and all referenced and applicable sections, with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements. Check marks (√) shall denote full compliance with a paragraph as a whole. If deviations from the specifications are indicated and therefore requested by the Manufacturer, underline each deviation and denote by a number in the margin to the right of the identified paragraph. Provide a detailed, written justification for each deviation. The Owner Representatives shall be the final authority for determining acceptability of requested deviations. The remaining portions of the paragraph not underlined will signify compliance with the specifications. Failure to include a copy of the marked-up specification sections, along with justification(s) for requested deviations with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration

B. Action Submittal Items for this Section:
   1. A copy specification section, with addendum updates included and each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements.
   2. If the specification includes the submittal item, revise the text of the submittal item to conform to the phrasing listed in the specifications.
   3. Manufacturer's data including materials of construction, construction details of equipment, wiring diagrams, weight of equipment, mounting, seismic bracing, and support.
   4. Drawings showing general dimensions and confirming the size of equipment, fixtures, motors and drives, and piping connections. (Shop drawings)
   5. Performance curves for pumps and fans developed for the specific application. Performance curves shall show speed, capacity, pressure, and power for specified conditions.
   6. Shop and field painting systems. Include manufacturer's descriptive technical catalog literature and specifications.
   7. Shop Drawings including the physical characteristics of all systems, equipment, and piping layout plans, and control wiring diagrams.
   8. Operation and Maintenance Information: Section 01 78 23.
   9. Samples, where required by the specification section.
   10. Rigid Equipment Mount Installation Checklist (Form 46 05 29-A).
   11. See Division 23 specifications sections for additional requirements.
   12. Certificates of Unit Responsibility.
   13. Sound Power rating for both fan inlet and outlets at rated capacity.

14. Installation forms in accordance with Section 43 05 13.
15. Testing forms in accordance with Section 23 05 93.

C. Informational Submittal for this Section:
   1. Structural Design and Anchorage: Section 01 73 24.

D. Operations and Maintenance Data and Manuals:
   1. Adequate operation and maintenance information shall be supplied as required in the Submittals section and Equipment Operating and Maintenance
   2. Manual Information section: Operation and maintenance manuals shall be submitted in accordance with the Submittals section and Equipment Operating and Maintenance Manual Information section.

E. Drawings and Data:
   1. The data and specifications for each unit shall include, but shall not be limited to, the following:
      a. Makeup Air Units
         1) Name of manufacturer.
         2) Type and model.
         3) Construction materials, thickness, and finishes.
         4) Input and output heating capacities.
         5) Filter velocities.
         6) Overall dimensions and required clearances.
         7) Net weight and load distribution.
         8) Performance curves with the specified operating point clearly identified for each unit, type, and model, with capacity in SCFM as the abscissa and brake horsepower, total static pressure, and efficiency as the ordinate. The fan curves shall include a family of curves for at least 5 different rotational speeds on a single chart.
         9) Certified AMCA standard test code sound power output data for the fan outlet and casing when operating at the specified volume flow rate. Sound data shall list dB re 10-12 watts in each octave band, with midrange frequencies starting at 63 Hz and ending at 8,000 Hz.
         10) Multiline wiring diagrams clearly indicating factory installed and field installed wiring with all terminals identified.
         11) Electrical requirements including voltage, number of phases, and amperage.
         12) Where specified, information on equipment manufacturers' representatives.
      b. Fans:
         1) Name of manufacturer.
         2) Type and model.
         3) Construction materials, thickness, and finishes.
         4) Overall dimensions and required clearances.
         5) Net weight and load distribution.

6) Performance curves with the specified operating point clearly identified for each unit, type, and model, with capacity in SCFM as the abscissa and brake horsepower, total static pressure, and efficiency as the ordinate. The fan curves shall include a family of curves for at least 3 different rotative speeds on a single chart.
7) Certified AMCA standard test code sound power output data for the fan outlet and casing when operating at the specified volume flow rate. Sound data shall list dB re 10-12 watts in each octave band, with midrange frequencies starting at 63 Hz and ending at 8,000 Hz.
8) Where specified, information on equipment manufacturers' representatives.

c. Equipment (all other types):
1) Name of manufacturer.
2) Type and model.
3) Construction materials, thickness, and finishes.
4) Manufacturer's performance data.
5) Overall dimensions and required clearances.
6) Net weight and load distribution.
7) Wiring diagrams.

d. Ductwork:
1) Duct fabrication drawings indicating dimensions of individual shop and field fabricated sections, top and/or bottom duct elevations, joint locations, and dimensions of duct from walls or column rows.
2) Pressure and seal classifications.
3) Reinforcement types and spacing.
4) Joint and seam types.
5) Hanger and support types, spacing, and attachment methods.
6) Access panel and door construction, sizes, and locations.
7) Duct sealant, adhesive, gasket, and tape information.
8) Product data for adhesives and sealants shall include VOC content.
9) Coatings.
10) Ductwork materials and thicknesses.
11) Coils
12) Product data demonstrating compliance with ASHRAE 90.1
13) Ductwork leakage test report.

e. Temperature controls:
1) Published descriptive data on each item of equipment and accessories, indicating all specific characteristics and options and identified with the designation used herein and on the Drawings.

2) Schematic control diagrams giving specific data on all settings, ranges, actions, adjustments, and normal positions. Although schematic, these diagrams shall, as closely as possible, represent the actual system with all significant equipment and devices identified and located relative to each other. These diagrams shall also show detailed multiline wiring with all terminals accurately identified. The wiring diagrams shall show the internal connections of the temperature control panels and all field wiring to equipment remote from the control panels, including wiring to Owner-furnished equipment. The wiring diagrams shall be complete, showing all connections necessary to place the temperature control systems in operation. Wiring diagrams shall be detailed to the degree necessary for field construction and shall include all related wiring.

3) Sequence of operation for each system corresponding to the control schematics.

4) Detailed panel construction drawings, including description of all materials and finishes, complete internal wiring and piping schematics, panel face layout, and complete data on all mounted components.

5) Space thermostat schedule indicating the types of covers and means of adjustment for each space.

6) Conduit and wire types.

7) Where specified, information on equipment manufacturers' representatives.

f. Seismic Design Requirements:

1) Confirmation of compliance with the requirements of the Special Provisions section.

g. Operation and Maintenance Data and Manuals:

1) Adequate operation and maintenance information shall be supplied as required in Section 01 78 23 and Section 01 33 00. Operation and maintenance manuals shall be submitted in accordance with Section 01 33 00. The operation and maintenance manuals shall be in addition to any instructions or parts lists packed with or attached to the equipment when delivered.

1.04 QUALITY ASSURANCE

A. Regulatory Requirements: Comply with the rules and regulations of Authorities Having Jurisdiction over the work specified herein, including all adopted state and local building codes including plumbing, mechanical, fire, building, and electrical.

B. Welding Qualifications:

1. All welding procedures and welding operators shall be qualified by an independent testing laboratory in accordance with the applicable provisions of AWS or ASME Standard Qualification Procedures.
2. All procedure and operator qualifications shall be in written form and subject to Engineer review.
3. Accurate records of operator and procedure qualifications shall be maintained by Supplier and made available to Engineer upon request.
4. The mechanical system installer shall be licensed as stipulated by the authority having jurisdiction.

C. Manufacturers Experience: Unless the equipment manufacturer is specifically named in this Section, the manufacturer shall have furnished equipment of the type and size specified which has been in successful operation for not less than the past 5 years.

D. Reference Standards:

1. Unless otherwise specified, references to documents shall mean the documents in effect on the effective date of the Agreement. They are part of this Section insofar as specified and modified herein. In the event of conflict between the requirements of this Section and those of the listed documents, the requirements of this Section shall prevail.
2. If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued.

Reference	Title
AABC	Associated Air Balance Council, National Standards for Total System Balance
ADA	Americans with Disabilities Act
AHRI	Air-Conditioning Heating & Refrigeration Institute
AMCA	Air Movement and Control Association
ANSI	American National Standards Institute
ASHRAE	American Society of Heating, Refrigerating and Air-Conditioning Engineers
ASME	American Society of Mechanical Engineers
ASPE	American Society of Plumbing Engineers
ASSE	American Society of Sanitary Engineering
ASTM	ASTM International
AWWA	American Water Works Association
CISPI	Cast Iron Soil Pipe Institute
CSA	CSA International
ETL	Electrical Testing Laboratories
EPA	Environmental Protection Agency
FDA	Food & Drug Administration
FM	Factory Mutual Global
IAPMO	International Association of Plumbing and Mechanical Officials
HI	Hydraulic Institute Standards
ISO	International Organization for Standardization
MSS	Manufacturers Standardization Society
NEBB	National Environmental Balancing Bureau, Procedural Standards for Testing Adjusting and Balancing of Environmental Systems
NEMA	National Electrical Manufacturers Association
NFPA	National Fire Protection Association
NSF	National Sanitation Foundation
OSHA	Occupational Safety and Health Administration
SMACNA	Sheet Metal and Air Conditioning Contractors' National Association, Inc.
UL	Underwriters Laboratories Inc.
IBC	International Building Code
IFC	International Fire Code

Reference	Title
IMC	International Mechanical Code
IPC	International Plumbing Code
UPC	Uniform Plumbing Code
UL 1995	Heating and Cooling Equipment

E. Unit Responsibility:

1. The Supplier shall furnish and install equipment assemblies made up of two or more components to be provided as a working unit by the unit responsibility manufacturer, where specified. The unit responsibility manufacturer shall coordinate selection, coordinate design, and shall provide all mechanical equipment assembly components such that all equipment components furnished under the specification for the equipment assembly, and all equipment components specified elsewhere but referenced in the equipment assembly specification, is compatible and operates reliably and properly to achieve the specified performance. Unless otherwise specified, the unit responsibility manufacturer shall be the manufacturer of the driven component equipment in the equipment assembly. The unit responsibility manufacturer is designated in the individual equipment specifications found elsewhere in this project manual. Agents, representatives or other entities that are not a direct division of the driven equipment manufacturing corporation shall not be accepted as a substitute for the driven equipment manufacturer in meeting this requirement. The requirement for unit responsibility shall in no way relieve the Supplier of his responsibility to the Owner's Representative and Owner for performance of all systems in the contracted scope of supply.
2. The Supplier shall ensure that all equipment assemblies provided for the project are products for which unit responsibility has been accepted by the unit responsibility manufacturer(s), where specified. Unit responsibility for related components in a mechanical equipment assembly does not require or obligate the unit responsibility manufacturer to warranty the workmanship or quality of component products not manufactured by them. Where an individual specification requires the Supplier to furnish a certificate from a unit responsibility manufacturer, such certificate shall conform to the content, form and style of Form 43 05 11-C specified in Section 01 99 90, shall be signed by an officer of the unit responsibility manufacturer's corporation and shall be notarized. No other submittal material will be processed until a Certificate of Unit Responsibility has been received and has been found to be satisfactory. Failure to provide acceptable proof that the unit responsibility requirement has been satisfied will result in withholding approval of progress payments for the subject equipment even though the equipment may have been installed in the work.
3. Complete assembly and installation drawings, and wiring and schematic diagrams, together with detailed specifications and data covering materials, parts, devices, and accessories forming a part of the equipment furnished, shall be submitted in accordance with Section 01 33 00 - Submittal Procedures. Device tag numbers indicated on the Drawings shall be referenced on the wiring and schematic diagrams where applicable.

F. Manufacturer’s Instructions:
   1. Follow manufacturer's written instructions.
   2. If in conflict with Construction Documents, obtain clarification.
   3. Notify the Owner’s Representative in writing before starting work.

G. Drawings:
   1. The Drawings shall be taken as diagrammatic, unless otherwise noted.
   2. Size of ductwork and pipes and general method of running them are shown, but it is not intended to show every offset and fitting nor every structural difficulty that may be encountered.

1.05 DELIVERY, STORAGE AND HANDLING

A. Shipping, handling and storage shall be in accordance with the Delivery, Storage, and Handling section.

1.06 COORDINATION

A. Supplier shall verify that each component of the HVAC system is compatible with all other parts of the system; that all piping, ductwork, equipment, and appurtenances are appropriate; and that all devices necessary for a properly functioning system have been provided.

B. Where two or more units of the same class of equipment are required, they shall be the product of a single manufacturer; however, all the component parts of the system need not be the products of one manufacturer.

C. Each manufacturer shall have a local service center, or with written consent of Engineer, shall be able to provide service from other locations within 24 hours. The service center shall be equipped and staffed to service the system and shall maintain a local parts supply.

D. Information on equipment manufacturers' representatives shall be included with the submittals.

E. The equipment as shown on the plans and specified herein, is based on the equipment furnished by one manufacturer. An equipment which is offered as a substitute to the specific requirements of these Specifications and which differs in detail and arrangement from that shown may require changes in design and construction. All costs which result from such changes in design and construction are to be borne entirely and unconditionally by the Contractor and/or the manufacturer; said costs to include but not be limited to structural, piping, mechanical and electrical changes and all engineering costs incurred as a result of the substitution, in the revision of Plans and Specifications, review of design changes by others, preparation of change orders, and any other costs directly resulting from said substitution.

1.07 APPURTENANCES

A. Furnish and install all necessary guides, inserts, anchors and assembly bolts, washers and nuts, hangers, supports, gaskets, couplings, and flanges; and all other appurtenant items shown on the Drawings, specified, or required for the proper installation and operation of the piping; devices included in or on the piping equipment; and piping accessories.

PART 2 PRODUCTS

2.01 SERVICE CONDITIONS

A. All equipment shall be designed and selected to meet the specified conditions.

2.02 MANUFACTURERS AND FABRICATION

A. Provide like items from one manufacturer, including but not limited to: fans, air handlers, air conditioning units, heat pump units, heaters, vibration isolation devices, etc.

B. Unless the equipment manufacturer is specifically named in this section, the manufacturer shall have furnished equipment of the type and size specified which has been in successful operation for not less than the past 5 years.

C. Anchor Bolts and Expansion Anchors: Section 05 05 20.
   1. Anchor Bolts and Expansion Anchors. Anchor bolts, expansion anchors, nuts, and washers shall be designed for lateral forces for both pullout and shear in accordance with the provisions of Section 05 05 20. Unless otherwise stated in the individual equipment specifications, anchor bolt, washer and nut materials shall conform to the requirements above with the provisions of Section 05 05 20 unless otherwise indicated on the Drawings.

2.03 ACCEPTABLE MANUFACTURERS

A. Acceptable manufacturers shall be as listed in the respective product description paragraphs.

2.04 PERFORMANCE REQUIREMENTS

A. See Section 43 05 11.

B. All air moving equipment fans shall be sized such that the correct SFCM is the output ACFM at the hottest, most humid condition with enough horsepower for the coldest inlet temperature. All controls shall have a temperature reset based on the outside temperature adjusting for the proper SCFM or ACH.

C. Coordination:
   1. Contractor shall verify that each component of the system is compatible with all other parts of the system; that all piping, ductwork, materials, fans, and motor sizes are appropriate; and that all devices necessary for a properly functioning system have been provided.

2. Where individual equipment paragraphs specify the requirement for local service, each manufacturer shall have a local service center, or with written consent of Owner's Representative, shall be able to provide service from other locations within 24 hours. The service center shall be equipped and staffed to service the system and shall maintain a local parts supply. Information on equipment manufacturers' representatives shall be included with the submittals.
3. Where several manufacturers' names have been listed in this section as possible suppliers, only the products of the first manufacturer listed have been checked for size, functions, and features.
4. The independent TAB agency shall be contracted prior to construction to do "balancability reports". The TAB agency shall perform periodic site walk throughs to identify items prior to testing. These include but are not limited to finding located or missing dampers and valves, variable air volume (VAV) box sizing, piping issues, duct sealing, and issues with building pressures.
5. Prior to official cleaning, testing, adjusting, and balancing, the mechanical contractor shall pre-test each section prior to any air balance agency testing, inspector witnessing, mechanical engineer witnessing, duct insulation installation, duct shafts are closed up, or any other structural construction that will have an impact is continued. Return air ducts and exhaust may be tested with positive pressure.
6. Equipment bearings shall be lubricated in accordance with the manufacturer's recommendations.
7. Mechanical contractor is responsible for coordinating with the project air balance agency.
8. For additional TABB coordination requirements consult Division 23 and the following Specifications:
    a. Testing Adjusting and Balancing for HVAC: Specification 23 05 93.
    b. Metal Ductwork and Accessories: Section 23 31 13.
    c. FRP Ductwork and Accessories: Section 23 31 16.
    d. Other ductwork as required
9. Air systems shall be complete and operating, with dampers, filters, ductwork, air outlet and inlet devices, duct-mounted equipment, and control components.

D. General Equipment Stipulations:
    1. The General Equipment Stipulations shall apply to all equipment and materials furnished under this section. If requirements in this specification differ from those in the Special Provisions section, the requirements specified herein shall take precedence.
    2. Unless otherwise noted, all equipment handling air shall meet the duct seal and leakage classes per 23 31 13. Manufacturer shall provide test data confirming cabinet construction can meet the requirement

E. Seismic Design Requirements: Seismic design requirements for products specified herein shall be as indicated in the Section 01 73 24.

F. Design Criteria:
   1. Design of HVAC equipment shall be based on the atmospheric conditions at the project site. Temperature, humidity, prevailing wind speed and direction, elevation, corrosive or contaminated environments, and human comfort shall be considered, as applicable.
   2. Equipment sizing shall be based on Environmental Conditions: See Section: 01 11 80

G. Dimensional Restrictions:
   1. Layout dimensions will vary between manufacturers. At least 3 feet of clear access space shall be provided on all sides of the unit
   2. Equipment shall be designed to operate at the elevation indicated ENVIROMENTAL CONDITIONS: See Section: 01 11 80. All equipment furnished for sites above 2000 feet above sea level shall be properly derated to operate and meet the specified capacities at the site conditions.

H. Type, Performance, Characteristics, Arrangement, Accessories: As noted in the Division 23 specification sections.

I. Fans and Shafts:
   1. Statically and dynamically balanced per AMCA 204 fan application category BV-3 (ISO 1940 Grade 6.3) or better and designed for continuous operation at maximum rated fan speed and motor horsepower.
   2. Each fan's operating selection point on the fan curves shall be selected to the right of the peak pressure/efficiency point and below the lowest point along the fan curve to the left of the peak pressure/efficiency point.

J. Electric Motor General Requirements:
   1. Designed for continuous operation in 40°C environment.
   2. For temperature rise in accordance with NEMA MG-1 limits for insulation class, service factor, and motor enclosure type.
   3. Type specified, scheduled, or noted for respective units.
   4. The use of ECM motors on HVAC equipment, up to 10 HP is acceptable with engineering concurrence. Coordinate with engineer

K. V-Belt Drives: 1.4 minimum service factor, fixed or adjustable type depending on motor horsepower and specifications for respective unit, generally as follows:
   1. 15 HP and under: Variable and adjustable pitch sheaves, selected so required rpm is obtained with sheaves set at mid-position.
   2. 20 HP and over: Fixed sheave, matched belts, rated as recommended by manufacturer or minimum 1.5 times nameplate rating of motor.
   3. Sheaves: Cast iron or steel, dynamically balanced, keyed to shaft.
   4. Belts: Oil-resistant, non-sparking, and non-static.
   5. Belt guard:
      a. Provide for all belt drives not enclosed in fan housing.
      b. Fabricated from diamond mesh expanded metal or sheet stock.
      c. Welded assembly with frame and mounting brackets.

d. With provisions for adjustment of belt tension, lubrication, and use of tachometer with guard in place.
e. Secured to fan or fan support without short-circuiting vibration isolation.
f. Meet OSHA requirements.

L. Provide ductwork and equipment supports, hangers, guides, and anchors as specified herein.

M. When standard hangers, supports, and accessories are not adequate the Contractor shall employ a registered Structural Engineer, registered in the state where the work is to be installed, to prepare design calculations for all such supports, hangers, and accessories for seismic restraint needed for the ductwork and equipment installation. Calculations and shop drawings shall be signed by the above-named engineer and submitted to the Owner's Representative.

N. Special Features for Hazardous Environments:
1. Provide for particular units when noted or scheduled on Drawings, spark proof fan wheels and explosion proof motors.

2.05 MATERIALS

A. Base contract upon furnishing materials as specified.

B. Materials, equipment, and fixtures used for construction are to be new, latest products as listed in manufacturer's printed catalog data and are to be UL, ETL, or CSA approved, or have adequate approval or be acceptable the Authorities Having Jurisdiction.

C. Articles, fixtures, and equipment of a kind to be standard product of one manufacturer.

D. Gas piping shall be A53 Grade B seamless or A106 Grade B.

2.06 COATINGS

A. Surface Preparation:
1. All fabricated surfaces from ferrous metal, except motors and speed reducers, shall be shop cleaned by sandblasting or equivalent, in strict conformance with the paint manufacturer's recommendations.
2. All mill scale, rust, and contaminants shall be removed before shop primer is applied.

B. Coatings shall be electrostatically coated (e-coat) and uniformly applied. The electro-coat process shall ensure complete encapsulation of all conductive surfaces with uniform dry film thickness. After e-coat cure, equipment shall receive a spray-applied, polyurethane black topcoat to prevent UV degradation of epoxy e-coat film. Immediately after completion of the test, the specimen must show no signs of blistering, wrinkling, cracking, or loss of adhesion and no sign of rust creepage beyond 1/8 inch on either side of the scratch mark. Cut edges of galvanized surfaces where hot-dip galvanized sheet steel is used must be coated with a zinc-rich coating conforming to ASTM D520, Type I.

C. Submit product data on the type coating selected, the coating thickness, the application process used to meet the requirements below and verification of conformance with the salt spray test requirement.
   1. Surface finish damaged during installation shall be repaired to the satisfaction of Engineer.

D. Coils/HX exposed to ambient
   1. No material bridging is allowed, including enhanced and micro-channel fin designs
   2. Submit the estimated heat transfer loss of the coil. Coating must be applied at either the coil or coating manufacturer's factory. Coating process must ensure complete coil encapsulation

E-Coating Requirements		
Coating Quality	**Test Procedure**	**Coating Performance (Nominal plus)**
Dry Film Thickness	ASTM D7091	1 mil
Water Immersion	ASTM D870	1000 hrs
Cross Hatch Adhesion	ASTM B3359	4B-5B Rating
Salt Spray	ASTM B117 ASTM B117-G85	6000 hrs 2000 hrs
Heat Transfer Reduction (Coils Only)	AHRI 410	<1%
Humidity	ASTM D1735	1000
Operating pH Range	N/A	3-12
Temperature		-40 F to 300 F (Coils Only) See 01 11 80
Weathering (topcoat)	ASTM 4587	2200

2.07 COLOR

A. Equipment shall have the manufacturer's standard color unless otherwise indicated in the schedules or specifications.

B. Equipment may use the manufacturer's finish if it meets the criteria above or otherwise indicated in the schedules or individual specifications.

2.08 ELECTRICAL

A. Electrical controls and disconnects shall be furnished and installed under the Electrical section, except where specified herein.

B. All electrical controls shall have enclosures suitable for the environment and NEMA rating as indicated on the electrical Drawings.

2.09 PIPING ACCESSORIES

A. General: Final pressure gauge and thermometer ranges shall be between 1.1 and 1.3 times the system operating conditions. Shut off if testing pressure exceeds the gauge range during testing.

B. Thermometers:
   1. Section 40 05 06.33: If not in the bid set, use the following:
      a. Thermometers shall conform to ASTM E1. Mercury shall not be used in thermometers.
      b. Thermometers shall be Weksler Instruments "Adjust Angle", Ashcroft "Series EI Everyangle" or Weiss Instruments, Inc. “Vari angle”.
      c. Thermometers shall be bimetal type and shall have a dial at least 4 1/2-inch diameter, with black markings on a white background. Pointer travel shall span not less than 200 degrees nor more than 270 degrees. Each thermometer shall have a stainless-steel case, bezel, fittings, and stem and shall be hermetically sealed, with external pointer adjustment and an acrylic or shatterproof glass window.
      d. Each indicator shall be furnished with an angularly adjustable frame for convenient viewing. Unless otherwise indicated, thermometer range shall be 0 to 200°F.
      e. Each thermometer shall be furnished with a stainless steel thermowell for installation in the piping systems. The thermowells shall have ¾-inch NPT thread mounts, a minimum pressure rating of 250 psig, and a nominal 4-inch insertion length.

C. Pressure Gauges:
   1. Section 40 05 06.33. If not in the bid set, use the following:
      a. Pressure gauges shall be Ashcroft "Duragauge 1279", Weksler, or Weiss Instruments, Inc.
      b. Except as modified or supplemented herein, all gauges shall conform to the requirements of ANSI B40.1 and ASME B40.100. Accuracy shall be ANSI Grade A or better.
      c. Gauges shall be indicating dial type with C type phosphor bronze Bourdon tube, stainless steel rotary geared movement, phenolic open-front turret, stainless steel or phenolic ring, case, adjustable pointer, and acrylic or shatterproof glass window.
      d. The dial shall be 4 1/2 inch in diameter with black markings on a white background. The units of measurement shall be psi and shall be indicated on the dial face. The pointer shall span not less than 200 degrees nor more than 270 degrees. The range shall be selected so that the normal operating reading is near the midpoint of the scale.
      e. Each gauge shall be provided with a threaded end ball-type shutoff valve as specified in the Ball Valves section.
      f. All stem-mounted gauges shall be provided with 1/2 inch NPT connections.

D. Diaphragm Seals:
   1. Pipe-mounted diaphragm seals shall be provided where indicated on the Drawings.
   2. Diaphragm seals shall be thread-attached type with cleanout ANSI Type 316 stainless steel diaphragm, plated carbon steel upper housing, and stainless steel lower housing.
   3. The diaphragm seal shall be of “continuous” design to safely contain the process fluid in the event of gauge failure or removal from the system under pressure.

4. The lower housing shall be provided with a tapped ¼ inch [6.3 mm] NPT flushing connection and an MxF stainless steel needle valve.
5. Each gauge isolator and the gauge served shall be factory assembled, filled with a suitable fluid, and calibrated as a unit.
6. Gauge isolators shall be as manufactured by Ashcroft “Type 101”, Weksler, or Weiss Instruments, Inc.

E. Pressure Switches and Transmitters: Section 40 73 00.

F. Flow Meters: Section 40 71 00.

2.10 ACCESS PANELS/DOORS

A. General: Provide flush mounting access panels as required for service of valves, drains, and test connections and other Item requiring maintenance or inspection. Where access panels are located in fire-rated assemblies of building, rate access panels accordingly. Ceiling access panels to be minimum 24-inch x 24-inch or required and approved size. Wall access panels to be minimum 12-inch x 12-inch or required and approved size. Babcock-Davis Series BN (non-rated), BI series (rated) or equal. All panels/doors shall incorporate doors/access panels with air seals suitable to provide airtight seal shall be provided between door and frame. The door swing shall be such as to open against system pressures.

2.11 AIR FILTRATION

A. General: Air filters in air handlers shall be 2-inch thick, MERV 8, pleated, disposable filters unless noted otherwise in Division 23 sections.

2.12 ROOF CURBS: FOR ROOF MOUNTED FANS AND AIR CONDITIONER UNITS

A. Each unit shall be provided with a prefabricated mounting curb.

B. AHRI Guideline B except as modified below
   1. 1997 version Table 1
      a. Up to 24” width shall be 16” above roof surface
      b. 49” to 60” Width shall be 30”
      c. See details in guide

C. Comply with local code requirements for minimum curb height, but in no case shall curb height be less than 16 inches, as measured from top of bar joist to top of curb, nor shall curb height be less than 8 inches as measured from top of roof membrane to top of curb. Roof curb to be manufactured of prime galvanized steel construction, 14 gauge as required, meeting ASTM A653/653M, with fully welded corners and with seams joined by continuous water and air tight welds. Roof curb shall be internally reinforced with angles 48" on center and factory installed wood nailer. Top of all roof curbs shall be level, with pitch built into curb when deck slopes. 2 inch by 4 inch (nominal dimension) pressure treated continuous wood nailers mechanically fastened with corrosion resistant fasteners at 12 inches on center to exterior face of curb. Shop prime welded connections with zinc-rich paint complying with SSPC-Paint 20. Label curbs with "INTAKE" designating to align with the intake of the equipment. Fans shall be labeled “FRONT” to designate where the equipment nameplate coincides. Frame duct openings with 18 gauge curb sections level with perimeter curb sections, minimum height 18"

D. The outer shell of the curb shall be formed with an integral cant strip and mounting flange. The bottom of the curb shall have a baseplate which encloses the lower edge of the roof insulation. A damper holding tray shall be provided. Provide curb for flat, pitched or ridged roof as required.

E. Coating per Section 09 90 00.

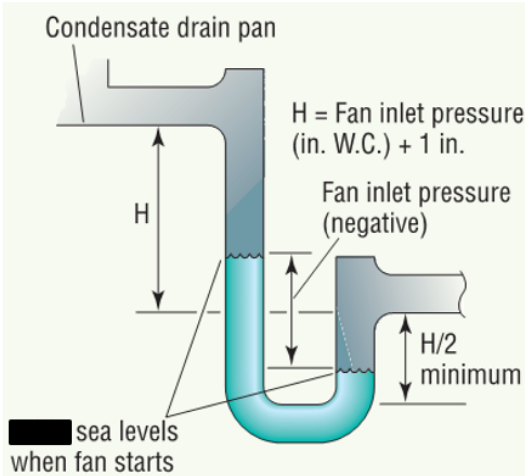
F. Insulate interior of the curb with 2 inches of 1.5-lb/cu ft neoprene-coated fiberglass insulation.

G. Provide seismic restraints to secure the unit to the curb in accordance with Section 01 73 24.

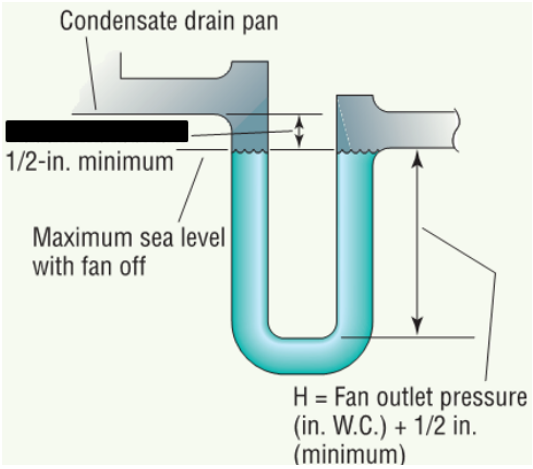
2.13 CONDENSATE DRAINS

A. Contractor to confirm that pad elevation is tall enough to meet the following minimum criteria with the equipment point of connection. Immediately contact the engineer if not.

B. Draw through unit



C. Blow Through unit



PART 3 EXECUTION

3.01 INSTALLATION

A. Equipment Mounting:
   1. Procedures: Section 43 05 13
      a. Install equipment for the Equipment Mounting Systems specified in Division 23 and in accordance with the Equipment Mounting Schedule specified in Section 43 05 13.
   2. Install equipment requiring access (i.e., drain pans, drains, control operators, valves, motors, cleanouts, and water heaters) so that they may be serviced, reset, replaced, or recalibrated. Do not install equipment in obvious passageways, doorways, scuttles, or crawlspaces which would impede or block intended usage.
   3. Install equipment and fixtures in accordance with manufacturer's installation instructions
      a. Maintain manufacturer's recommended clearances.
      b. Install plumb, level, and firmly anchored to vibration isolators per manufacturer’s requirements.
      c. Obtain installation instructions from manufacturer prior to rough-in of equipment and examine instructions thoroughly.
      d. When requirements of installation instructions conflict with Construction Documents, request clarification from the Engineer prior to proceeding with installation. This includes proper installation methods, sequencing, and coordination with other trades and disciplines
   4. Furnish and install all supports, bracing and blocking required for the proper installation of the work specified.
   5. Furnish and install miscellaneous supports/metal required for installation of equipment, ductwork, piping, and vents

B. Piping and Equipment Identification: Divisions 33, 40, and 43.

C. Piping and Valves:

1. Coordinate work to account for expansion and contraction of piping materials and building as well as anticipated settlement or shrinkage of building. Install work to prevent damage to piping, equipment, and building and its contents. Provide piping offsets, loops, expansion joints, sleeves, anchors, or other means to control pipe movement and minimize forces on piping. Verify anticipated settlement and/or shrinkage of building. Verify construction phasing, type of building construction products, and rating for coordinating installation of piping systems.
2. Include provisions for servicing and removal of equipment without dismantling piping.
3. Provide unions, couplings, or flanges where equipment is installed in piping. Unions shall be dielectric unions or couplings at points of connection of ferrous to non-ferrous metal piping, unions, couplings, or flanges shall by dielectric type.
4. Provide a shut-off stop valve in the branch of every water, air, gas, or vacuum pipe service upstream of every fixture or outlet.
5. Except for condensate drains, provide valves where equipment drain connections are furnished and carry the discharge pipe to the nearest floor drain, drain trench, or sump. Where no receptacle for drain exists, install drain piping to 1-inch above the floor. Drain piping and valve materials shall conform to the requirements of the system served.
6. Install escutcheons secured to pipe with set-screw where pipes or tubing pass through exposed walls or ceilings.
7. Penetration Firestopping: Section 07 84 13.

D. See the Division 23 specifications sections for additional requirements.

E. In plenums, provide plenum rated materials that meet the requirements to be installed in plenums. Immediately notify the Owner's Representative of discrepancy.

F. Where equipment motors are to be electrically interlocked with other equipment for simultaneous operation, utilize equipment wiring diagrams to coordinate with electrical systems so that proper wiring of equipment involved is affected.

3.02 COATINGS

A. Per this specification and Section 09 90 00.

3.03 CLEANING

A. Prestartup Requirements: Section 01 74 23. If not in the bid set, use the following as a minimum

1. Prior to testing, thoroughly clean the inside of each completed piping system of all dirt, loose scale, sand, and other foreign material.
2. Cleaning shall be by sweeping, flushing with water or blowing with compressed air, as appropriate for the size and type of pipe.
3. Flushing shall achieve a velocity of at least 3 feet per second.
4. The contractor shall install temporary strainers, temporarily disconnect equipment, or take other appropriate measures to protect equipment while cleaning piping.

B. Post Startup Requirements:
   1. At the completion of the testing, all equipment, pipes, ductwork, valves, and fittings shall be cleaned of grease, debris, metal cuttings, and sludge. Any stoppage, discoloration, or other damage to parts of the building, its finish, or furnishings shall be repaired by Contractor at no additional cost to Owner.
   2. Upon completion of the duct system cleaning, the duct system shall be visually inspected for cleanliness to verify no visible contaminants are present to the satisfaction of Owner's Representative.
   3. If the visual inspection is inconclusive, then additional tests in accordance with the National Air Duct Cleaners Association shall be performed. Any ducts that are considered not to be clean by the Owner's Representative shall be re-cleaned and re-tested. Any damaged materials or surfaces shall be repaired or replaced.
   4. A report shall be provided indicating the successful cleaning of the ductwork, method used to determine the cleanliness, and results of any tests is required.

3.04 STARTUP REQUIREMENTS

A. System equipment shall be subject to preliminary field tests as indicated in Equipment Startup and Checkout section

3.05 FIELD TESTING AND INSPECTIONS

A. Test all HVAC systems and arrange for inspection by the Authorities Having Jurisdiction.

B. General:
   1. Furnish all equipment, material, personnel, and supplies to perform the tests and make all taps and other necessary temporary connections.
   2. Field performance tests shall be conducted for each system to demonstrate each is functioning as specified and to the satisfaction of Owner's Representative.
   3. All tests shall be conducted in a manner acceptable to Owner's Representative and shall be repeated as many times as necessary to secure Owner's Representative acceptance of each system.
   4. If inspection or tests indicate defects, the defective item or material shall be replaced, and the inspection and tests shall be repeated.
   5. All repairs to piping shall be made with new materials.
   6. Caulking of threaded joints or holes will not be acceptable.

C. Perform leakage tests on all pipe installed in this project or on any alterations or extensions of existing. Furnish all equipment, material, personnel, and supplies to perform the tests and make all taps and other necessary temporary connections. Leakage tests shall be performed on all piping at a time agreed upon and in the presence of the Owner. All visible leaks shall be repaired, regardless of the test results.

D. The test pressure, allowable leakage, and test medium shall be as specified for the piping systems. Test pressure shall be measured at the highest point on the line, except that pressure at lowest point shall not exceed pipe manufacturer's rated test pressure, unless specifically noted otherwise.

E. All visible leaks shall be repaired, regardless of the test results.

F. Perform following operations and checks before units are operated for any purpose:
   1. Verify shipping blocking and bracing have been removed.
   2. Verify unit is secure on mountings and supporting devices and connections for ductwork, electrical, etc. are complete. Verify proper thermal overload protection is installed in motors, starters and disconnects.
   3. Perform specified cleaning and adjusting. Disconnect fan drives from motors, verify proper motor rotation, and verify fan wheel free rotation and smooth operation of bearings. Reconnect fan drive systems, align belts, and install belt guards.
   4. Lubricate bearings and other moving parts with factory-recommended lubricants.
   5. Verify manual and automatic volume control dampers are positioned properly and that fire and smoke dampers in related ductwork are in full-open position.
   6. Disable automatic temperature control operators, where applicable.

G. Startup equipment, in accordance with manufacturer's startup instructions, and in presence of manufacturer's representative. Test controls and demonstrate compliance with requirements. Replace damaged or malfunctioning controls and equipment.
   1. Do not place equipment in sustained operation prior to initial balancing of systems.
   2. Conduct tests of equipment and systems to demonstrate compliance with requirements specified. Document tests and include in Operation and Maintenance Manuals.

H. The equipment and controls of this Section shall be completely tested, adjusted, and placed in operating condition.

I. Retest equipment and controls, as necessary, during the progress of the work. No work shall be covered until it is properly tested and made tight.

J. Replace damaged or malfunctioning controls and equipment with new. Refurbished is not acceptable.

K. When about to turn the apparatus over to the Owner, put all parts of the apparatus in perfect working order and thoroughly clean out all parts of the equipment.

L. Clean exterior and interior surfaces of each unit. Vacuum clean fan wheel and surfaces exposed to the air handled by the unit.

M. Check damper operation and linkages. Adjust for proper damper operation.

N. Air filters which are subject to a pressure loss exceeding the dirty filter values shall be removed and replaced. The spare air filters furnished with equipment shall not be used as the replacement filters. Dirty filter values shall be as follows:

Filter Type	Dirty Filter Conditions
1 inch pleated	1.0 inch water column
2 inch pleated	1.0 inch water column

O. Perform ductwork pressure test prior to air balancing per 23 30 00 Sheet Metal Ductwork and Accessories.

P. All heating, ventilating, and air conditioning systems installed under this Section shall be carefully adjusted by a qualified Air Balancing Contractor to deliver and exhaust air quantities as specified or described herein while maintaining the spaces served at the design temperature and design air pressure differentials. A final balancing report shall be produced and submitted to the Owner showing the airflow SCFMs, fan statics, and motor amperages.

3.06 TESTING, TRAINING, AND COMMISSIONING

A. In accordance with Section 01 45 20 – Equipment and System Performance and Operational Testing

B. Upon completion of work and adjustment of equipment and systems testing, demonstrate to the Owner's Representative that equipment furnished and installed or connected under provisions of these Specifications functions in manner required.

C. Manufacturer's Field Services:
   1. Furnish services of a qualified person at time approved by Owner's Representative, to instruct maintenance personnel, correct defects or deficiencies, and demonstrate to satisfaction of Owner's Representative that entire system is operating in satisfactory manner and complies with requirements of other trades that may be required to complete work.
   2. Complete instruction and demonstration prior to final job site observations.

D. TABB Procedures and Requirements: See Section 23 05 93.

3.07 ROOF CURBS

A. Roof curbs to be mounted level on roof in accordance to NRCA manuals and details. Secure to structure per engineered/sealed seismic installation details.

B. Seal openings between curb, roof opening, ducts, electrical conduits, piping, and building interior.

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SECTION 23 05 93

TESTING, ADJUSTING, AND BALANCING FOR HVAC

PART 1 GENERAL

1.01 DESCRIPTION

A. This section specifies the labor and services necessary to test, adjust, and balance under actual operating conditions air and hydronic systems design flow rates. Nothing herein shall be construed as relieving the contractor of his overall responsibility of this portion of the work.

1.02 QUALITY ASSURANCE

A. References:

1. This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.
2. Unless otherwise specified, references to documents shall mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid (or on the effective date of the Agreement if there were no Bids). If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued. Where document dates are given in the following listing, references to those documents shall mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, discontinued or replaced.

Reference	Title
NEBB	Procedural Standards for Testing Adjusting and Balancing of Environmental Systems
AABC	National Standards for Total System Balance
ASHRAE 70	Standards–Methods of Testing for Rating the Air Flow Performance of Outlets and Inlets

B. Testing Agency:

1. The Contractor shall procure the services of an independent air and hydronic balancing and testing agency, belonging to the Associated Air Balance Council (AABC) or the National Environmental Balancing Bureau (NEBB), to perform air and hydronic balancing, testing and adjustment of systems. The Contractor shall submit a copy of the National Project Certification Performance Guaranty, issued to the testing agency by the AABC, as a part of the balancing report specified in paragraph 2.01 Report Requirements.

C. Codes And Standards:
   1. The Contractor shall comply with applicable procedures and standards of the certification sponsoring association:
      a. "National Standards for Field Measurements and Instrumentation, Total Systems Balance, Air Distribution-Hydronics Systems," AABC.
      b. "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems", NEBB.
      c. "Method of Testing for Rating the Air Flow Performance of Outlets and Inlets," ASHRAE.
   2. Calibration and maintenance of instruments and accuracy of measurements shall comply with the requirements of the standards.

1.03 SPECIAL REQUIREMENTS

A. Tests and adjustments shall include the complete testing and balancing of all hydronic systems and heating, ventilating, and air conditioning systems and necessary adjustments to the heating, air conditioning, and ventilating equipment to accomplish the specified design flow rates.

B. Should any apparatus, material or work fail to meet the specified requirements in these tests, the Contractor shall make the necessary corrections and retest the apparatus, material, or work at no additional cost to the Owner.

1.04 BALANCING

A. General:
   1. The Contractor shall review plans and specifications prior to testing and balancing the air and hydronic systems. The contractor shall submit a proposed approach and schedule for approval prior to the start of testing and balancing work. Characteristics to be tested and adjusted to conform to the values specified include the following:
      a. Total airflow rates delivered by fans and air-handling units.
      b. Flow rates at all grilles, registers, diffusers, supply and exhaust and return ducts.
      c. Distribution patterns at air outlets.
      d. Total water flow rates at each heating and cooling coil, control valve, and pump.
      e. Capacity and temperature rise or drop across each heating and cooling coil.
      f. Operation and modulation of each control valve.

B. Airflow Rate Measurements:
   1. Airflow rates shall be obtained by adjustment of the fan speeds, dampers, or registers. All flow rates shall be measured with supply, return, and exhaust systems operating with heating and cooling coils wet, with filter bank resistance midway between the design values specified for clean and dirty filters, with auxiliary systems in operation and with all doors and windows closed.
   2. Flow rates at grilles, registers, branch ductwork and air distribution patterns shall be tested in strict accordance with ASHRAE Standard-70.

C. Water Flow Rate Measurements:

1. Total water flow rates shall be measured at each heating coil, cooling coil, unit heater, heat recovery coil, control valve and pump. Water flow rates shall be obtained by adjustment of balancing cocks, valves, and fittings. All flow rates shall be measured with control valves 100 percent open. Pump capacities shall be determined by differential pressure measurement. Temperature shall be measured across the heat transfer elements in the system.

1.05 SUBMITTALS

A. The following information shall be provided in accordance with Section 01 33 00:

1. A copy of this specification section, with addendum updates included, and all referenced and applicable sections, with addendum updates included, with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements. Check marks (✓) shall denote full compliance with a paragraph as a whole. If deviations from the specifications are indicated, and therefore requested by the Contractor, each deviation shall be underlined and denoted by a number in the margin to the right of the identified paragraph, referenced to a detailed written explanation of the reasons for requesting the deviation. The Construction Manager shall be the final authority for determining acceptability of requested deviations. The remaining portions of the paragraph not underlined will signify compliance on the part of the Contractor with the specifications. Failure to include a copy of the marked-up specification sections, along with justification(s) for any requested deviations to the specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration.
2. Sample copy of each of the NEBB or AABC report forms.
3. Proposed approach and schedule of testing and balancing work as specified in paragraph 1.04 General.
4. A description of each air and hydronic system including equipment to be balanced.

PART 2 PRODUCTS

2.01 BALANCING REPORT

A. Report Data:

1. The final certified balancing report shall include the following actual field-verified data:
    a. Equipment data
        1) Manufacturer and model, size, arrangement, class, location, and equipment number.
        2) Motor horsepower, voltage, phase, and full load amperage.
        3) Fan cfm, static pressure, rpm, and operating motor BHP.
        4) Pump gpm, discharge pressure, suction pressure, pressure change across pump, total discharge head, gpm at major equipment and operating motor BHP.
    b. Duct size, supply or exhaust recorded cfm, velocity, pressure measurements, location of all measurements.

c. Pipe size, recorded gpm, velocity, pressure measurements, balancing valve size and model, location of all measurements.

d. Terminal units

1) Manufacturer and model, supply or exhaust, location, and identification number.

2) Recorded and design cfm.

3) Recorded and design noise levels and velocities, where specified.

B. Report Requirements:

1. Each individual final reporting form must bear the signature of the person who recorded the data and that of the supervisor of the reporting organization.
2. One certified organization shall perform the testing and balancing services.
3. All instruments which were used shall be listed and identified including the last date each was calibrated.

C. Final Report:

1. Final report shall be submitted prior to Contractor's request for final inspection. In addition to providing all specified data and information on applicable reporting forms, report shall include the following:

a. A schedule for testing and balancing parts of the systems which must be delayed due to seasonal, climatic, occupancy, or other conditions beyond control of the Contractor. Delayed work shall be completed as early as the proper conditions will allow, after consultation with the Construction Manager.

b. Due to delayed testing, reports shall be submitted after execution of those services.

c. A total balance report shall include the following components:

1) General Information and Summary

2) Instrument Calibration

3) Air Systems

4) Hydronic Systems

5) Temperature Control Systems

6) Special Systems

7) Sound and Vibration Systems

8) Record drawings with specified and measured flow rates

2.02 CERTIFICATE OF COMPLETION

A. At completion of testing and balancing, Contractor shall submit a Certificate of Compliance stating that each apparatus, device, outlet, and system has been tested, adjusted, and balanced so that it is operating in conformance with manufacturer's recommendations and with the specified conditions.

2.03 PRODUCT DATA

A. The following information shall be provided in accordance with Section 01 33 00:
   1. The balancing report specified in paragraph 2.01.
   2. Documentation to confirm compliance with codes and standards.
   3. NEBB or AABC certification

PART 3 EXECUTION

3.01 GENERAL

A. The balancing agency shall conduct the above field tests in the presence of the Construction Manager.

B. Following completion of testing and balancing the system shall be left in proper working order, replacing belt guards, closing access doors, closing doors to electrical switch boxes, and restoring thermostats to specified settings.

3.02 PERFORMANCE OF WORK

A. Air Systems:
   1. General: Testing, adjusting, and balancing shall be performed after the system installation is complete but prior to acceptance of the project.
   2. Measurements: The Contractor shall perform the following:
      a. Measure and adjust air supply and exhaust units to deliver at least 100 percent of the design air volume at 100 percent cooling.
      b. Measure static air pressure conditions on fans, including filter and coil pressure drops, and total pressure across the fan.
      c. Adjust fan speeds and motor drives within drive limitations, for required air volume. Set a speed to provide air volume farthest distance from the fan without excess static pressure. Check draw amps of fans on initial start-up. If running amps exceed nameplate, shut off motor immediately, notify Construction Manager, and make necessary drive changes as directed.
      d. Evaluate building and room pressure conditions to determine adequate supply and return air conditions.
      e. Airflow rates shall be measured with supply, return, and exhaust systems operating with heating and cooling coils wet, with filter bank resistance midway between design values specified for clean and dirty filters, with auxiliary systems in operation. The deflection pattern of supply outlets shall be adjusted to ensure uniform air distribution throughout the space served.
      f. Airflow rates supplied, exhausted, or returned shall be within plus or minus 5 percent of the design values specified.
   3. Systems to Be Balanced:
      a. Existing Upblast Exhaust Fan 72-EF-1-1
      b. Existing Upblast Exhaust Fan 72-EF-1-2

3.03 FINAL INSPECTION

A. Following completion of testing and balancing, but prior to submitting the balancing report, the Contractor shall recheck, in the presence of the Construction Manager, random selections of data water and air quantities, air motion, and sound levels recorded in the report. Points and areas for recheck shall be as selected by the Construction Manager. Measurement and test procedures shall be as approved for work forming basis of the report.

B. Selections for recheck will not exceed 25 percent of the total tabulated in the report, except for special air systems, as described in Section 23 31 13, which may require 100 percent recheck for safety reasons.

C. In the event the report is rejected, all systems shall be readjusted and tested, new data recorded, new reports submitted, and new inspection test made.

D. Following acceptance of the reports by the Construction Manager, the Contractor shall permanently mark all damper positions, circuit balancing valves, and balancing valves so that they can be restored to their correct position if disturbed at any time. If a balancing device is provided with a memory stop, it shall be set and locked. Devices shall not be marked until after final inspection.

END OF SECTION

SECTION 23 31 13

METAL DUCTS

PART 1 GENERAL

1.01 DESCRIPTION

A. Scope:
   1. This section specifies plenums, sheet metal housings, ductwork, equipment connections, reinforcing and other devices required to make the air distribution systems complete and operational.

B. Type:
   1. Ductwork and appurtenances shall be designed and fabricated specifically for the applications described under the conditions specified.

C. Design Criteria and Considerations:
   1. General: Unless otherwise specified, sheet metal gage, reinforcing, hanger and support systems, ductwork joint types and other basic design construction details shall be in accordance with the 1985 Sheet Metal and Air Conditioning Contractors National Association (SMACNA) HVAC Duct Construction Standards. Ductwork shall be fabricated to the configurations and dimensions specified. Dimensions specified indicate net free area; dimensions shall be increased by the thickness of the lining where internal lining is required.
   2. Low Pressure Ductwork: Low pressure ductwork shall convey air with a velocity less than 2000 fpm and maximum static pressure of 2 inches of water column. Low-pressure ductwork shall conform to 2-inch w.c. pressure class.
   3. Medium Pressure Ductwork: Medium pressure ductwork, where specified, shall convey air with a velocity greater than 2000 fpm and a maximum static pressure of 6 inches of water column. Medium pressure ductwork shall conform to 6-inch w.c. pressure class.
   4. System Leakage: All joints shall be sealed as required to limit total system leakage to a maximum of 1 percent of the specified equipment airflows.
   5. Change In Duct Size: Change in duct size shall be made by a uniformly tapering section. The change in direction of the tapering section shall not be more than 1 inch in 5 inches of run, unless otherwise specified.
   6. Bends In Duct: With the exception of mitered bends, all bends in ducts shall have inside radii equal to the duct width or diameter. Double wall turning vanes shall be provided at all 90-degree mitered bends.
   7. Duct Sleeves: Whenever ducts extend through concrete or masonry walls, floors or ceilings, they shall be provided with a sleeve as specified in paragraph 2.04. Concrete inserts shall be provided before pour to support all ductwork under this section.
   8. Duct Openings: Access doors or hand holes shall be provided in ducts at locations to reach modulating dampers, fusible links, controllers and any other moveable devices in the ducts. The opening shall be 1 inch less duct size or of adequate size to reach in and maintain these devices. Two-inch diameter nipples with threaded caps shall be welded to the duct where specified or directed by the engineer for balancing the system.

9. Vibration Isolation Flexible Connections: Flexible connections shall be provided at duct connections to motor-driven air handling equipment and other locations specified. Flexible connections shall be UL approved and provided with the necessary angle, straps, bolts, clips, or other fasteners to secure the flexible material to the equipment and ducts. Flexible connections exposed to the weather shall be provided with approved sheet metal weather covers.

1.02 QUALITY ASSURANCE

A. References:

1. This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.
2. Unless otherwise specified, references to documents shall mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid (or on the effective date of the Agreement if there were no Bids). If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued. Where document dates are given in the following listing, references to those documents shall mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, discontinued or replaced.

Reference	Title
ASHRAE CH 1	Handbook - Equipment Volume, Duct Construction
ASHRAE CH 33	Handbook - Fundamentals Volume, Duct Design
ASTM A525	General Requirements for Steel Sheet, Zinc-Coated (Galvanized) by the Hot-Dip Process
ASTM A527/A527M	Steel Sheet, Zinc-Coated (Galvanized) by the Hot-Dip Process, Lock-Forming Quality
ASTM B209	Aluminum and Aluminum Alloy Sheet and Plate
ASTM B211	Aluminum and Aluminum Alloy Bar, Rod, and Wire
ASTM B308	Aluminum - Alloy 6061-T6 Standard Structural Shapes, Rolled or Extruded
NFPA 90A	Standard for the Installation of Air Conditioning and Ventilating Systems
SMACNA	HVAC Duct Construction Standards Metal and Flexible
UBC	Uniform Building Code
UMC	Uniform Mechanical Code
UL 181	Factory-made Air Ducts and Connectors

B. Requirements Of Regulatory Agencies:

1. Ductwork construction, installation, and air system performance shall comply with UMC, ASHRAE CH-1 and CH-33, and SMACNA Duct Construction Standards.

1.03 SUBMITTALS

A. The following information shall be provided in accordance with Section 01 33 00:

1. A copy of this specification section, with addendum updates included, and all referenced and applicable sections, with addendum updates included, with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements. Check marks (✓) shall denote full compliance with a paragraph as a whole. If deviations from the specifications are indicated, and therefore requested by the Contractor, each deviation shall be underlined and denoted by a number in the margin to the right of the identified paragraph, referenced to a detailed written explanation of the reasons for requesting the deviation. The Construction Manager shall be the final authority for determining acceptability of requested deviations. The remaining portions of the paragraph not underlined will signify compliance on the part of the Contractor with the specifications. Failure to include a copy of the marked-up specification sections, along with justification(s) for any requested deviations to the specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration.
2. An 8-1/2-inch by 11-inch manual with detail sheets or catalog data of flexible duct connectors, duct sleeves, duct access doors, turning vanes, volume dampers, supports, hangers, etc.

PART 2 PRODUCTS

2.01 GENERAL

A. The Contractor shall provide all ductwork, plenums, and all auxiliary work and products of any kind necessary to make the HVAC systems complete and ready for operation. Ductwork shall comply with the following restrictions and conditions:

1. Ductmate systems shall be used as an option by the Contractor for low pressure systems only.
2. Snap lock seams shall not be permitted.
3. Where space conditions permit, full radius turns shall be used at offsets.
4. Turning vanes shall be provided where tees, bends, and elbows are not 1-1/2 times the width at centerline and in all rectangular elbows.
5. Ductwork elbows, takeoffs, and fittings shall be in accordance with the SMACNA and ASHRAE standards for the pressure class and conditions specified.
6. Visible duct deflection, loss of shape, or unwarranted noise or vibration resulting from faulty or inadequate support, reinforcing, metal gage, fabrication, or joint spacing shall be corrected at no expense to the Owner.

2.02 MATERIALS

A. Low and Medium Pressure Systems:

Component	Material
Duct	Galvanized steel, ASTM A525 and ASTM A527 or aluminum, alloy 3003-H14, conforming to ASTM B209 and ASTM B211
Duct sleeve	Galvanized steel, 10 gage or aluminum, alloy 3003-H14, conforming to ASTM B209 and ASTM B211

Flexible duct connector	Noncombustible, weather and ozone resistant, abrasion-proof woven fiberglass fabric with coating weighing not less than 24 ounces per square yard. Maximum flame spread rating of 25, smoke rating of 50 for all materials including connecting tape, etc. UL 181 approved.
Turning vanes	Galvanized steel or aluminum to match duct material.
Hangers and supports, rivets and bolts, reinforcing	Galvanized steel or aluminum, alloy 6061-T6 conforming to ASTM B308 to match duct material.

2.03 JOINTS AND REINFORCING

A. Transverse stiffeners and joints shall be appropriately spaced to maintain duct cross-section integrity in accordance with the pressure class specified and at the prevailing operating velocities. After joints are crimped, they shall be further secured by bottom punching or riveting. Longitudinal seams shall be Pittsburgh lock and shall be cross-broken outward. Intake, or exhaust, side ducts shall be cross-broken inward. Discharge ducts shall be cross-broken outward. All plenums and casings shall be similarly cross-broken and further reinforced with 1-inch x 1-inch x 1/8-inch angles running diagonally between joints, riveted to the casings.

B. Low pressure ductwork shall have slip joints. Medium pressure ductwork shall have flanged or welded joints. Joints shall not interfere with airflow in the ducts. Interior ducts shall be suitably braced and stiffened at floor and roof penetrations as well as over their unsupported length in a manner designed to maintain duct integrity and limit vibration and noise in accordance with recognized standards of the industry.

C. Ducts over 17 inches in largest dimension shall be cross-broken or beaded on all four sides. In ducts over 72 inches at each transverse joint 3/8-inch stay rods shall be installed. Spacing between rods or rods on side of duct shall not exceed 48 inches.

2.04 DUCT SLEEVES

A. Sleeve flanges shall not be less than 4 inches wide and shall be installed tight against each side of the barrier. Sleeves shall be 2 inches larger than the duct or external duct insulation. The space between the duct (or insulation) and the sleeve shall be packed with fiberglass or material of original wall. Duct flanges not less than 4 inches wide shall be installed tight against the wall on each side and fastened to the duct sleeves.

2.05 HANGERS AND SUPPORTS

A. General:
   1. Duct support spacing shall be in accordance with the SMACNA standards for the pressure class and conditions specified and prevailing in the system. Supports shall be spaced to prevent visible duct deflection and loss of system integrity. Aluminum ductwork shall be constructed with strength and dimensional stability comparable to conventional steel duct. In the absence of other criteria, aluminum sheet and reinforcing shall have a moment of inertia three times greater than that recommended for steel ductwork. Supports shall be designed in accordance with Section 01 73 24.

B. Concealed Ceiling Spaces:
   1. Rectangular ductwork shall be supported with metal strap hanger screwed to the sides and bottom of duct. One strap each side with minimum of two screws in side and one in bottom of each strap.

C. Exposed Areas:
   1. Rectangular ductwork shall be supported with shelf angle trapeze hanger or unistrut with rods or angles by welding or bolting. Sway bracing shall be provided, minimum of one at right angle to each duct run.
   2. Round ductwork shall be supported with two half round bands with rods bolted to the bands. Sway bracing shall be provided, minimum of one at right angle to each duct run.

2.06 ACCESS DOORS

A. The doors shall be rigid and shall be provided with airtight gaskets and shall not vibrate or cause noise under service. Doors in insulated ducts shall be the insulated type. Doors shall be continuous hinged type with ventlock latch on outside.

B. Plenum access doors shall be 24 inches by 66 inches or as specified.

2.07 FLEXIBLE CONNECTIONS

A. Flexible connection joints shall be airtight and have a minimum allowance of 1-inch slack all around. Flexible connections shall be designed to be removed from the line and be reinstalled without disassembling adjacent ductwork.

B. Connections shall be installed with a minimum 4-inch clearance between metal parts on fan connections, equipment connections, and our distribution devices.

2.08 TURNING VANES

A. Turning vanes shall be 2-inch blades for ducts up to 18 inches in either dimension and shall be 4-1/2-inch blades for larger ducts. All turning vane assemblies shall be finished with an air-dried phenolic corrosion resistant coating prior to installation. All turning vanes shall be constructed of double thickness vanes.

2.09 DAMPERS

A. Manually operated, opposed blade or single blade, quadrant-type balancing dampers shall be provided in each branch duct take-off after leaving the main duct on low pressure systems. Balancing dampers shall be provided on medium pressure systems where specified. Splitter dampers shall be provided only where specified.

B. Single-blade dampers shall be constructed for ducts 9-1/2 inches by 30 inches and smaller. Opposed blade dampers shall be constructed with a maximum blade size of 12 inches by 72 inches.

2.10 DUCTWORK COATING

A. Exposed uninsulated or internally insulated ductwork shall be coated on all external surfaces in accordance with Section 09 90 00 except in mechanical rooms.

PART 3 EXECUTION

3.01 INSTALLATION

A. Ductwork shall be installed in accordance with SMACNA and NFPA. All ductwork indicated on the drawings is schematic. Therefore, changes in duct size, duct configuration, and location may be necessary to conform to field conditions.

B. Ductwork and accessories shall be installed to provide a system free from buckling, warping, breathing, and vibration. Ductwork installation shall permit installation of other required services without piercing, crimping, or reducing duct sizes. Where space conditions permit, full radius turns shall be used at offsets. The inside of all ducts visible through grilles and registers shall be painted flat black.

C. All ductwork shall be made airtight. Flanged joints shall be sealed with closed-cell neoprene gaskets compressed between mating flanges. All other joints and seams shall be sealed with liquid or mastic type sealants. Taped joints shall not be permitted. All joints shall comply with the requirements of SMACNA Seal Class A.

D. All duct fittings shall be fabricated with continuously welded seams and joints.

3.02 TESTS

A. Tests shall be as specified in Section 23 05 93. Duct test holes with patches in ducts shall be provided where directed or necessary for testing and balancing purposes.

3.03 DUCTWORK SCHEDULE

A. Ductwork material shall be as follows:

Area	Material	Design criteria
Building 72:		
Supply air	Match existing	Low-pressure

END OF SECTION

SECTION 23 31 16

FIBERGLASS REINFORCED PLASTIC (FRP) DUCTWORK

PART 1 GENERAL

1.01 SUMMARY

A. Scope: This Section specifies Fiberglass Reinforced Plastic (FRP) ductwork for foul air systems.

1.02 SUBMITTALS

A. Procedures: Section 01 33 00.

B. Items to be Submitted for this Section:
   1. Shop Drawings
   2. Ductwork:
      a. Statement of resins (liner, structural and corrosion liner) and reinforcing proposed for use.
      b. Certification from the manufacturer of the selected resin system that the selected resin and catalyst systems are appropriate for the service conditions of the duct systems as detailed within this Section.
      c. Design calculations, stamped by an engineer registered in the State of Washington, and complete fabrication details shall be submitted to Owner for approval.
      d. For Filament-Wound Laminates:
         1) Helix angle.
         2) Glass content range.
         3) Strand yield.
         4) Strand by inch in the winding band.
         5) Ply thickness.
         6) Amount of chop or unidirectional roving interspersed with winding, if any, and location within laminate.
      e. For All Fabricated Parts:
         1) Construction type.
         2) Laminate thickness.
         3) Ply sequences.
         4) Glass content range.
      f. For All Secondary Overlays (Both Interior and Exterior):
         1) Laminate thickness.
         2) Ply sequences and widths.
         3) Construction details for all other special configurations and fabricated parts.
      g. Pressure, vacuum, and temperature rating of duct.
      h. Dimensions of subassemblies to be shipped.

i. Manufacturer's data and descriptive literature for duct accessories.
j. Drawings at minimum 3/16-inch scale, full size, showing layout, support locations, and field joint locations.
k. Stamped and signed structural engineering design calculations.
l. Information, details, and requirements for installation and support of duct and torque values for flange bolting.
m. Name of manufacturer.

3. Supports:
   a. Location plan.
   b. Type and details.
   c. Materials of construction.
   d. Stamped and signed structural engineering design calculations for special supports.
4. Expansion Joints/Flexible Connectors:
   a. Type and model.
   b. Materials of construction.
   c. Force required for expansion/contraction.
   d. Name of manufacturer.
5. Butterfly Dampers:
   a. Statement of resins and reinforcing proposed for use.
   b. Complete damper shop drawings illustrating component configuration, dimensions, and material list.
   c. Pressure, vacuum, and temperature rating.
   d. Certified damper leakage test results by AMCA-approved laboratory in accordance with AMCA 500-D standards, pressure drop characteristics, and operator torque requirements.
   e. Materials of construction.
   f. Total weight including operator.
   g. Type and model.
   h. Name of manufacturer.
6. FRP round duct sample, minimum size 12 inches diameter by 12 inches long representing the quality of workmanship and glass/resin being quoted. These will be retained for quality comparison on materials shipped to jobsite.
7. Qualifications:
   a. Fabricator: List of references substantiating experience.
   b. Installer: Manufacturer's certification that installer is qualified for installation work.
8. Manufacturer's installation instructions.
9. Procedure for protection and handling of materials prior to shipping.
10. Certificates:
    a. Manufacturer's certificate of compliance.
    b. Manufacturer's certificate of proper installation.

11. Manufacturer's factory inspection report.
12. Quality control forms.

1.03 QUALITY ASSURANCE

A. Reference Standards:
   1. This Section incorporates by reference the latest revisions of the following documents. They are part of this Section insofar as specified and modified herein. In case of conflict between the requirements of this Section and those of the listed documents the requirements of this Section shall prevail.
   2. Unless otherwise specified, references to documents shall mean the documents in effect on the effective date of the Agreement. If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued.

Reference	Title
AMCA 500 D	Laboratory Methods of Testing Dampers for Rating
ANSI B16.1	Cast Iron Pipe Flanges and Flanged Fittings Classes 12, 125, and 250
ASME B18.22.1	Plain Washers
ASTM A193/A193M	Standard Specification for Alloy-Steel and Stainless Steel Bolting Materials for High-Temperature Service
ASTM A194/A194M	Standard Specification for Carbon and Alloy Steel Nuts for Bolts for High-Pressure or High-Temperature Service, or Both
ASTM C582	Standard Specification for Contact Molded Reinforced Thermosetting Plastic (RTP) Laminates for Corrosion-Resistant Equipment
ASTM D2563	Standard Practice for Classifying Visual Defects in Glass Reinforced Plastic Laminate Parts
ASTM D2583	Standard Test Method for Indentation Hardness of Rigid Plastics by Means of Barcol Impressor
ASTM D3982	Standard Specification for Contact Molded "Fiberglass" (Glass Fiber Reinforced Thermosetting Resin) Duct and Hood
ASTM E84	Standard Test Method for Surface Burning Characteristics of Building Materials

B. Shipment and Storage:
   1. Do not ship ducting by nesting small diameter components inside larger diameter components.
   2. Protect flanged sections by bolting to wooden blinds 2 inches greater than outside diameter of flange.
   3. For nonflanged components, use either rigid plugs inside ends to prevent deflection or protect with wooden boxes.
   4. Crate materials whenever practical prior to shipment.
   5. Firmly fasten and pad components shipped to prevent shifting or flexing of components while in transit.

C. Qualifications:
   1. Fabricator Qualifications: Minimum 5 years' experience fabricating FRP ductwork.
   2. Installer Qualifications: Minimum 5 years' experience installing FRP ductwork.

PART 2 PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS/PRODUCTS

A. Candidate manufacturers of FRP Ductwork include: Spunstrand, Bondstrand, Ershigs Inc., or Approved Equal. The FRP Ductwork manufacturer's standard models or products may require modification to conform to specified requirements.

B. Candidate manufacturers of vinyl ester resin include: Ashland Chemical Hetron FR 992, Dow Chemical Dekrane 510-A, or Approved Equal. The vinyl ester resin manufacturer's standard models or products may require modification to conform to specified requirements.

C. Candidate manufacturers of expansion joints include: Holz Rubber Company Inc., or Approved Equal. The expansion joint manufacturer's standard models or products may require modification to conform to specified requirements.

D. Candidate manufacturers of butterfly dampers include: Swartwout Model 914, Ershigs Inc., or Approved Equal. The butterfly damper manufacturer's standard models or products may require modification to conform to specified requirements.

E. Candidate manufacturers of zero-leak butterfly dampers include: Spunstrand ZL Series, Ershigs Inc. Type B, or Approved Equal. The zero leak butterfly damper manufacturer's standard models or products may require modification to conform to specified requirements.

F. Candidate manufacturers of hand actuators include: Swartwout Dyna-Torque Model DT2, or Approved Equal. The hand actuator manufacturer's standard models or products may require modification to conform to specified requirements.

2.02 PERFORMANCE REQUIREMENTS

A. Service Conditions:
   1. Air Stream Contents: Saturated air streams containing hydrogen sulfide in concentrations up to 50 ppm at 115 degrees F.
   2. Pressure and Vacuum: Design conditions are 20 inches water column pressure and 12 inches water column vacuum.

B. Design Requirements:
   1. General:
      a. Conform to ASTM D3982 and NBS PS15-69.
      b. Duct manufacturer's design for round section, including duct wall thickness and stiffeners.
      c. Round duct shall have a safety factor of 2 to 1 for pressure and 2 to 1 for vacuum service.

d. A 1/4-inch laminate shall have the following minimum physical properties:

Design Requirement	Ref Standard	Value
Minimum Ultimate Tensile Strength	ASTM D638	12,000 psi
Minimum Flexural Strength	ASTM D790	19,000 psi
Minimum Flexural Modulus of Elasticity (tangent)	ASTM D790	800,000 psi

2. Field Conditions:
   a. Design of ductwork shall include field verification of existing conditions, space limitations, and required connections.
   b. Verification of field conditions shall be completed prior to fabrication.
3. Rectangular Duct and Transitions:
   a. Rectangular duct design criteria shall be submitted to the Owner for review and approval.
   b. Where transitions, rectangular duct or other special system components not specifically detailed in this Section are needed, fabricator shall be responsible for the design of the component.
   c. Minimum safety factor for critical buckling due to vacuum shall be 5:1.
   d. Deflection of flat panels shall be limited to 1 percent of the width of the panel.
   e. Corrosion liner shall not be included in structural calculations.
4. FRP Ducting Detail Drawings: Use the following Details in conjunction with requirements set forth herein. When conflict exists between details herein and referenced standards, details herein take precedence. Details are attached to the end of this Section.
   a. Detail 1: FRP Duct Stiffener Installation.
   b. Detail 2: FRP Drilled Flange - Duct Drilling.
   c. Detail 3: 1-1/2" FRP Drilled Flange – For Duct Drain.
   d. Detail 4: Duct Drain and Pressure Indicator Attachment Flange.
   e. Detail 5: Blind Flanges.
   f. Detail 6: 1-1/2" Dia. Duct Drain and P.I. Nozzle Installation.
   g. Detail 7: FRP Butt Joints.
   h. Detail 8: FRP Tee Joints.
   i. Detail 9: FRP Miter Joints.
   j. Detail 10: FRP Lateral Joints.
   k. Detail 11: FRP Butt Joints and Tee Joints Charts.
   l. Detail 12: Damper Nozzle Installation.
   m. Detail 13: 90 and 45 Degree Elbows. All elbows shall be long radius.
   n. Detail 14: Eccentric and Concentric Reducers.
   o. Detail 15: 90 Degree Tee and Cross.

2.03 MATERIALS

A. FRP Ductwork materials of construction shall be as follows:

Component	Material
Resin	Premium corrosion-resistant, fire-retardant, vinyl ester resin. Minimum 3% antimony trioxide.
Chopped Strand Mat	Type E glass, minimum 1-1/2 ounces per square foot, with silane finish and styrene soluble binder
Continuous Roving for Chopper Gun Spray-Up	Type E glass
Woven Roving	Type E glass, nominal 24 ounces per square yard, 4 by 5 weave, with silane type finish
Continuous Roving for Filament Winding	Type E glass with a silane type finish

B. Fastener (bolts, nuts, washers, backing strips) shall be type 316 stainless steel.

C. Gaskets shall be Neoprene or Buna-N.

D. Expansion joint / flexible connection materials of construction shall be as follows:

Component	Material
Expansion joint material	Neoprene or Buna-N
Backing rings	Type 316 stainless steel

E. Butterfly damper materials of construction shall be as follows:

Component	Material
Resin	To match connecting ductwork
Frames	FRP
Blades	FRP
Axles	Continuous FRP rod
Bearings	Molded PTFE
Blade stops	FRP bar
Blade seals	Neoprene
Shaft seals	Neoprene
Hand actuator worms	Heat-treated carbon steel
Hand actuator worm wheels	Cast ductile iron
Hand actuator shaft	Stainless steel
Hand actuator shaft / worm wheel seals	Buna-N
Bolts	Type 316 stainless steel
Nuts	Type 316 stainless steel
Washers	Type 316 stainless steel

F. Ductwork Fabrication:

1. Resin:
   a. Resin shall be premium corrosion-resistant, fire-retardant vinyl ester resin.

b. FRP fabrications shall not exceed a flame spread index of 25 and smoke development rating of 50 when tested in accordance with ASTM E84 Tunnel Test.

c. Structural wall resin shall contain a minimum of 3 percent antimony trioxide to achieve the designed low flame spread index requirement.

d. Special Catalyst: In accordance with the recommendations of the resin manufacturer for the intended service.

e. Add ultraviolet absorbers to surfacing resin to improve weather resistance.

f. Color: Use no dyes, pigments, or colorants, except in the exterior gel coat. Exterior gel coat shall be selected by Owner from the fabricator's standard color palette.

2. Method of Construction:

a. Inner Surface: Inner surface exposed to the exhaust environment shall be a resin-rich liner between 0.01-inch and 0.02-inch thick obtained by using one layer of Nexus veil saturated with the specified resin.

b. Interior Layer: Resin-rich interior surface of nominal 100 to 120 mils thick for the entire corrosion barrier, using chopped strand glass mat or chopped glass roving backing the veil. Use no additive in the corrosion barrier. The inner surface and interior layer shall have a glass content of 27 percent plus or minus 5 percent.

c. Structural Layer: Fabricated using either hand lay up construction per ASTM D3982 or filament wound. Structural layer shall not be less than the following thicknesses:

Diameter (inches)	Thickness (inches)
6 - 20	1/8
20 - 28	3/16
30 - 58	1/4

d. Exterior Coat: Resin rich with no exposed raw fibers. For interior duct, the final coat shall be a factory applied intumescent coating to achieve the designated results for low smoke development. For exterior duct, resin coat with ultraviolet (UV) inhibitor.

3. Reinforcement:

a. Fittings and special sections shall be reinforced or their shell thickness increased where combined stresses due to internal pressure and bending will exceed maximum stress.

b. Shell thickness or reinforcing shall be as required to keep combined stresses below maximum recommended.

4. Flanges or resin rich bell and spigot connections are preferred method of joining sections of duct where inside overlay is not possible.

5. Butt Joints:

a. Butt joints shall be overlaid both inside and outside.

b. Butt joints shall only be permitted in duct sections that are accessible for inside overlay.

c. Field butt joints, when needed, shall be made at locations at least 12 inches from any increasing or decreasing cross section of duct.

d. Minimum width of overlay shall be as indicated in Detail 7 herein.
e. Butt joints shall be built up in successive layers and shall be crevice-free in accordance with ASTM D2563.
f. Width of the first layer shall be 4 inches (minimum).
g. Successive layers shall increase uniformly to the specified minimum total width of overlay; centered on the joint.
h. Crevices shall be filled with resin, leaving a smooth inner surface.
i. Comply with Detail 7 for joint tolerance and Detail 11 for overlay criteria.
j. The inner surface of butt joints shall be free of cracks and crazing, with a smooth finish, with an average of not more than two pits per square foot (pits shall be less than 1/8-inch diameter and maximum of 1/32-inch deep), and covered with sufficient resin to prevent exposure of inner surface fabric.
k. Minimal waviness is permissible provided surface is smooth and free of pits.

6. Flanges:
   a. Flange dimensions (except thickness) and drilling patterns for all flanges that connect to equipment, expansion joints, or dampers are to correspond to ASME/ANSI B16.1, Class 25.
   b. All flanges to be factory drilled.
   c. Flange dimensions and drilling patterns for all duct joints are to correspond to ASTM D3982 for FRP ductwork, or Details 2 herein, whichever is more stringent.
   d. Back Face of Flanges shall be spot-faced, flat and parallel to the flange face, and of sufficient diameter to accept an SAE metal washer under the bolt head or nut.
7. Furnish gussets on flanged nozzles from ducts.
8. Duct and Fittings:
   a. Round: ASTM D3982.
   b. Rectangular:
      1) Contact molded to a thickness as dictated by structural calculation.
      2) Reinforcing with angles or tees is acceptable to meet required pressure/vacuum service.
   c. Joints: Butt wrapped unless otherwise indicated on Contract Drawings except flanged at connections to expansion joints, butterfly dampers, blast gates, or mechanical equipment to facilitate disassembly.
   d. Fittings:
      1) Plain end or flanged, manufacturer's standard sizes.
      2) Comply with Details 13, 14, and 15 herein.
      3) Chemical resistance equal to or greater than the duct.
      4) Bends with a centerline radius of 1.5 times the diameter shall be either smooth radius elbows formed over a removable mold or mitered elbows fabricated from straight duct with the following mitre segments:
         a) Bends up to 30 Degrees: 1 mitre/2 gore.
         b) 31-Degree to 60-Degree Bend: 2 mitre/3 gore.
         c) 61-Degree to 90-Degree Bend: 4 mitre/5 gore.

5) Provide integral turning vanes at elbows where indicated on Contract Drawings.

e. Flanges shall have a minimum thickness of 3/4-inch, where connecting to equipment, expansion joints, or dampers. Flange thickness shall comply with Details herein.

f. Transitions:

1) Glass-fiber reinforced, with wall stiffness equal to that of duct, designed using the pipe design criteria.

2) Maximum deflection of a side shall be less than 1 percent of the width of that side at the design internal pressure.

3) Shop-installed reinforcing such as ribs or angles shall be used if required to meet deflection requirements.

9. Cure products to at least 90 percent of the minimum Barcol hardness specified by resin manufacturer.

2.04 FEATURES

A. Fasteners:

1. Bolts:

a. ASTM A193/A193M, ANSI coarse thread series, Grade B 8M hex head.

b. Length such that after installation bolts will project 1/8-inch to 3/8-inch beyond outer face of the nut.

2. Nuts: ASTM A194/A194M, Grade 8M.

3. Washers: ANSI B18.22.1, flat.

4. Backing strips, drilled for the above bolting requirements, shall be employed for all connections at fans, demisting sections, and wherever shear or moment loads may be encountered on duct connections.

B. Gaskets: Full-face, ASTM D2240, Type A Durometer 50-70, 3/16-inch minimum thickness.

C. Inspection Plates:

1. Removable inspection plates, made of the same material as the parent duct, not less than 6 inches square or 8 inches round, bolted with all stainless steel hardware, at all turning vane locations and condensate drain low points.

2. Gasketed and shall make an airtight seal with the parent duct.

3. Submit location, fabrication, and installation details.

D. Expansion Joints/Flexible Connections:

1. Provide where indicated on Contract Drawings or as required for proper duct installation.

2. Type: W-design configuration with integral flanges suitable for service with FRP duct.

3. Backing Rings: 3/8 inch thick, 2 inches wide, ANSI B16.1, Class 25 diameter and drilling.

4. Length: 12 inches, flange-to-flange (unless otherwise indicated on Drawings).

5. Extension: 0.5 inch.

6. Compression: 2.0 inches.
7. Lateral Offset: 1.0 inch.
8. Thickness: 1/4 inch, minimum.

E. Supports and Hangers: Comply with Section 40 05 07, Section 40 05 07.13, and Section 40 05 07.16.

F. Butterfly Dampers:
   1. Design Requirements: Each damper shall be designed for the following conditions:
      a. Air Temperature Range: 40 to 105 degrees F.
      b. Design Pressure: match ductwork.
   2. Construction:
      a. Blades: Stiffeners as required.
         1) 36-inch and Under: 0.25 inch thick.
         2) Above 36 Inches: 0.50 inch thick.
      b. Axles: 6 inches extension beyond frame; stiffeners as required.
      c. Flanges: Flanges shall comply with PS 15-69 Table 5 at design pressure of 25 psi and shall have ANSI B16.1, Class 25 diameter and drilling.
      d. Bolts: ASTM A193/A193M, ANSI B18.2.1, ASA coarse thread series, Grade B 8M heavy hex head. Length such that after installation bolts will project 1/8-inch to 3/8-inch beyond outer face of the nut.
      e. Nuts: ASTM A194/A194M, ANSI B18.2.2, Grade 8M.
      f. Washers: ANSI B18.22.1, flat.
      g. Single-blade type complete with channel-type frame, close-fitting blade, full-length axle, and bearings.
      h. Same inside dimensions as the connecting ductwork.
      i. Axles not less than 3/4-inch in diameter and continuous through the damper.
      j. Maximum leakage rate of 5.25 cubic feet per minute per square foot of damper area, at a differential pressure of 30 inches WC.
   3. Zero Leak Dampers:
      a. Design and construction requirements for zero leak dampers shall conform to requirements for butterfly dampers except as noted.
      b. Zero leak dampers shall be leak free at a differential pressure of 30 inches WC for a period of 1 hour.
      c. Minimum damper blade thickness shall be equal to flange thickness specified in this section.
      d. Share seal shall be Viton O-ring.
   4. Hand Actuators:
      a. Provide for dampers larger than 24-inch diameter:
      b. Hand actuators shall be worm geared driven.
      c. Actuators shall be totally enclosed, weather-proof, and permanently lubricated in a die-cast aluminum housing.
      d. Housing shall be epoxy coated in the factory with a minimum dry film thickness of 8 mils.

e. Hand wheel sizes shall be computed assuming a maximum rim effort of 80 pounds.

f. Actuator shall be bolted to damper with stainless steel bolts as required.

g. Number of turns of hand wheel in order to rotate blade 90 degrees: Minimum of 4 and maximum of 12.

h. Provide indicating arrows identifying direction of rotation for correct operation of dampers with "Open" and "Close" clearly marked. Indication shall be legible and of substantial durability.

i. Chain Wheels:

1) Dampers installed with shaft centerlines more than 5 feet 6 inches above the floor shall be provided with chain wheels and operating chains.

2) Chain wheels shall be equipped with a chain guide which will permit rapid handling of the operating chain without "gagging" of the wheel.

3) Reasonable side pull on the chain shall be permitted by the chain wheel without "gagging" of the wheel.

4) Provide suitable actuator extensions, if necessary, to prevent interference of chain and adjacent piping or facilities below.

5) Operating chains shall be hot-dip galvanized carbon steel. Loop and extend within 4 feet of the floor below damper.

6) Provide and install galvanized tie-back hooks on adjacent pipe supports or structures to hold operating chains out of walkways or access areas when damper is not in operation.

G. Drains:

1. In addition to drains shown on the drawings, drain sumps, with 1-1/2 inch minimum flanged outlets, shall be provided at all low points.
2. All drain sumps shall be fitted with a 1-1/2 inch ball valve.

H. Marking:

1. Identify each duct component with the fabricator's name, resin, minimum thickness, and date of manufacture.
2. Use permanent marking. Seal decals and labels into laminate exterior with resin.
3. For piece marking used for installation, use oil-based paint for easy removal.

I. Additional Equipment:

1. Construction details are provided on the drawings included in this Section.
2. If additional details or items are required (such as transitions, etc.) the Contractor shall submit such details.
3. Approval is required prior to the start of fabrication.

PART 3 EXECUTION

3.01 INSTALLATION

A. All material and equipment shall be installed as specified and as required by the applicable state and local codes.

B. Cut, fit, and install in accordance with duct manufacturer's recommendations.

C. Ductwork shall be free of vibration when in operation. All necessary vibration isolation devices shall be provided and installed by Contractor.

D. Install plumb and straight. Unless otherwise indicated, install ductwork sloped at minimum 1 percent slope for proper condensate drainage in direction of flow or 2 percent slope in opposite direction of flow.

E. Joining systems shall be suitable for installation without the prior need for sanding.

F. Field Joining Materials: FRP duct manufacturer shall supply all materials needed for any required FRP duct field joining. Supply of these materials shall be in accordance with the requirements of this Section. Provide material in kit form; one kit per joint.

G. Field Joining: Any required field joining shall be accomplished by a competent person in accordance with the requirements of this Section.

H. Install in accordance with Section 40 05 07, Section 40 05 07.13, and Section 40 05 07.16.

I. Provide for expansion and contraction.

J. Large elbows and terminal ends of ducts shall be supported independently.

K. Flexible connections as described herein shall be provided between fans and ductwork, and elsewhere as indicated on the layout drawings.

L. Certify installation on Manufacturer’s Certificate of Proper Installation.

M. Anti-seize thread compound on all nuts and bolts.

N. Damper axles in horizontal position unless otherwise necessary for proper installation.

O. Flange bolts shall be tightened to slightly compress gaskets without disturbing the flanges in order to make a good seal. A flat washer shall be installed under each nut and bolt head.

P. Proper alignment and grade of ductwork shall be maintained by use of laser beam equipment or surveying instruments. Surveying instruments shall be utilized for verifying laser equipment accuracy due to thermal deflection from differences between the ground temperature and the air temperature within the pipe.repair/restoration

3.02 QUALITY ASSURANCE

A. Provide the following information if requested/required:
   1. Two sample cutouts demonstrating 50 to 60 mils as manufactured to the standard used in the fabricator's Factory Mutual approval. Structural laminate to be filament wound. Samples to be a minimum of 8-inch diameter cut out, and a 12-inch diameter piece of duct at least 12 inches long complying with ASTM C582.
   2. Two copies of the fabricator's ISO 9001-based quality control manual.

B. All FRP ductwork shall be fabricated and installed by qualified, experienced mechanics, who have a minimum of 5 years' experience with the lay-up, fabrication, and jointing of this type of material.

C. Factory Inspection:
   1. Owner shall be given access to the FRP ductwork and all quality control records during fabrication and upon completion for the purpose of verifying compliance to the Contract Documents.
   2. The Owner shall maintain the right to tour the FRP duct manufacturer's plant anytime that fabrication is in progress prior to final shipment. The Owner may exercise the option, without any advance notice; to tour the plant and inspect all stages of fabrication to ensure that quality control is being maintained.
   3. Inspection by Owner does not relieve any responsibility of the fabricator to meet the requirements of this Specification.
   4. Final Inspection: The Owner may carry out a final inspection of the equipment prior to shipment. Fabricator shall give the Owner a minimum of 5 days' advance notice of scheduled ductwork shipment. Prior to final inspection by Owner, the ductwork shall be cleaned of all foreign material, and shall be in a position that allows easy access and viewing.

D. Acceptance:
   1. Lack of compliance with any aspect of the Specifications and Drawings will be grounds for rejection of the equipment.
   2. Repair of Rejected Equipment: The Owner, prior to implementation, must approve repair procedures. No more than 5 percent of the surface area of each FRP duct component may be repaired.

E. Quality Assurance Report:
   1. The fabricator’s quality control manager will provide the Owner with a complete quality control report for the job. The report will be available within 15 days after the final parts are shipped.
   2. The fabricator will have available, after each shipment, the completed QC sheets for review upon request at any time.

3.03 QUALITY CONTROL

A. Field join ductwork only when ambient temperature is above 55 degrees F and below 100 degrees F.

B. Testing:
   1. All ductwork shall be leak tested using a small high pressure blower with a calibrated orifice and manometer. The blower shall maintain at least 20 inches static pressure during the test. Leakage in the entire system shall be no more than 1 percent of the design scfm for that part of the system.
   2. Seal all audible leaks.
   3. Notify Owner of all tests with a minimum of a 24-hour notice.
   4. Provide necessary fittings, blind flanges, etc. to isolate sections of duct and to enable all sections of ductwork to be tested.

C. Manufacturer's Services:
   1. The FRP duct manufacturer shall have a representative on-site beginning with the installation of the ductwork to supervise installation of the FRP duct system. The representative shall remain on-site no less than two 8-hour days to witness installation of all ductwork to ensure the installer is employing the proper procedures.
   2. The manufacturer's representative shall instruct the installer on the proper installation procedures.

D. Cleaning: Blow ductwork clean using system fans; purged continuously for not less than 48 hours at a flow rate not less than design flow rate. If required, system fan shall be throttled on inlet side to prevent motor overload. Temporary screen shall be installed on system fan inlet to protect fan from entering debris.

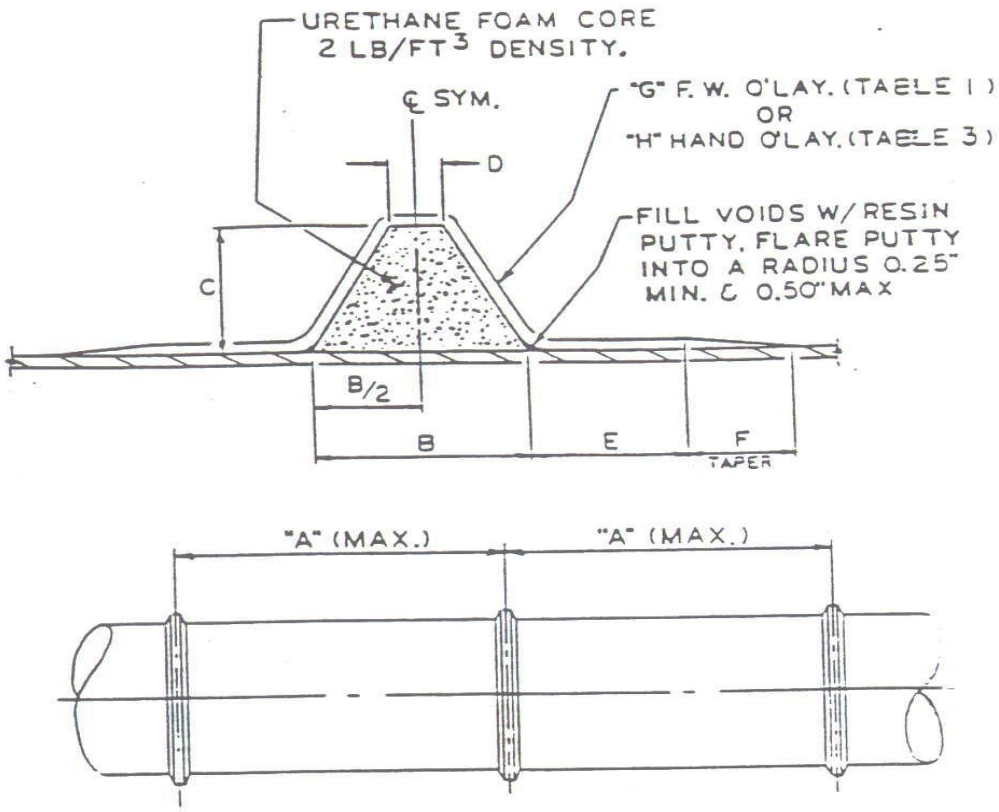
E. Testing: In addition to any testing herein, perform all testing for this product or system consistent with the requirements of Section 01 45 23, the applicable codes, and the manufacturer's current Quality Assurance program.

3.04 SUPPLEMENTS

A. The supplements listed below, following "End of Section," are a part of this Specification.
   1. Detail 1: FRP Duct Stiffener Installation.
   2. Detail 2: FRP Drilled Flange - Duct Drilling.
   3. Detail 3: 1-1/2" FRP Drilled Flange – For Duct Drain.
   4. Detail 4: Duct Drain and Pressure Indicator Attachment Flange.
   5. Detail 5: Blind Flanges.
   6. Detail 6: 1-1/2" Dia. Duct Drain and P.I. Nozzle Installation.
   7. Detail 7: FRP Butt Joints.
   8. Detail 8: FRP Tee Joints.
   9. Detail 9: FRP Miter Joints.
   10. Detail 10: FRP Lateral Joints.
   11. Detail 11: FRP Butt Joints and Tee Joints Charts.
   12. Detail 12: Damper Nozzle Installation.
   13. Detail 13: 90 and 45 Degree Elbows. All elbows shall be long radius.

14. Detail 14: Eccentric and Concentric Reducers.
15. Detail 15: 90 Degree Tee and Cross.

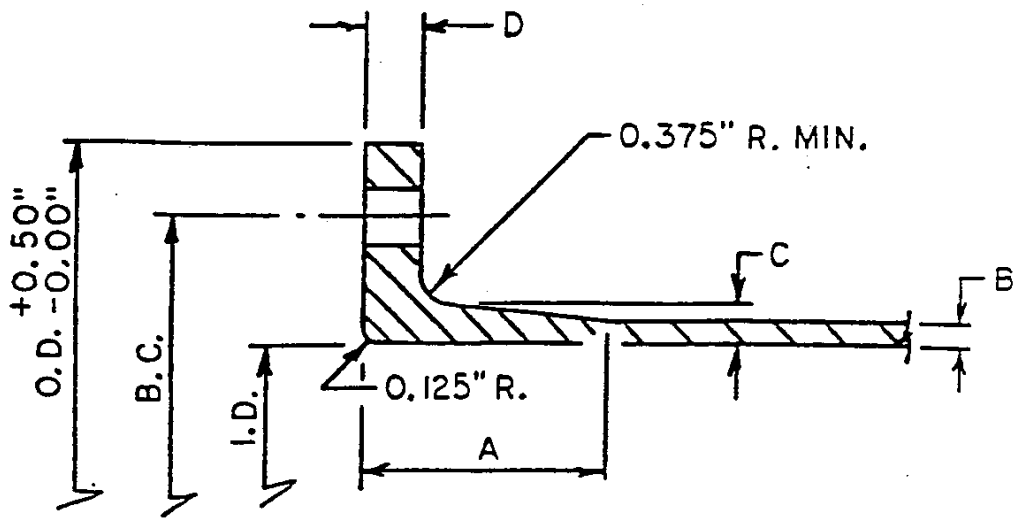
END OF SECTION



DUCT SIZE	A	B	C	D	E	F	G	H
42"	15'-0"	2"	2"	1"	4"	2"	0.28"	0.29"
48"	15'-0"	2"	2"	1"	4"	2"	0.28"	0.29"
54"	15'-0"	2"	2"	1"	4"	2"	0.28"	0.29"
60"	15'-0"	3"	3"	1"	4"	2"	0.28"	0.29"
72"	10'-0"	3"	3"	1"	4"	2"	0.28"	0.29"

FRP DUCT STIFFENER INSTALLATION

DETAIL - 1

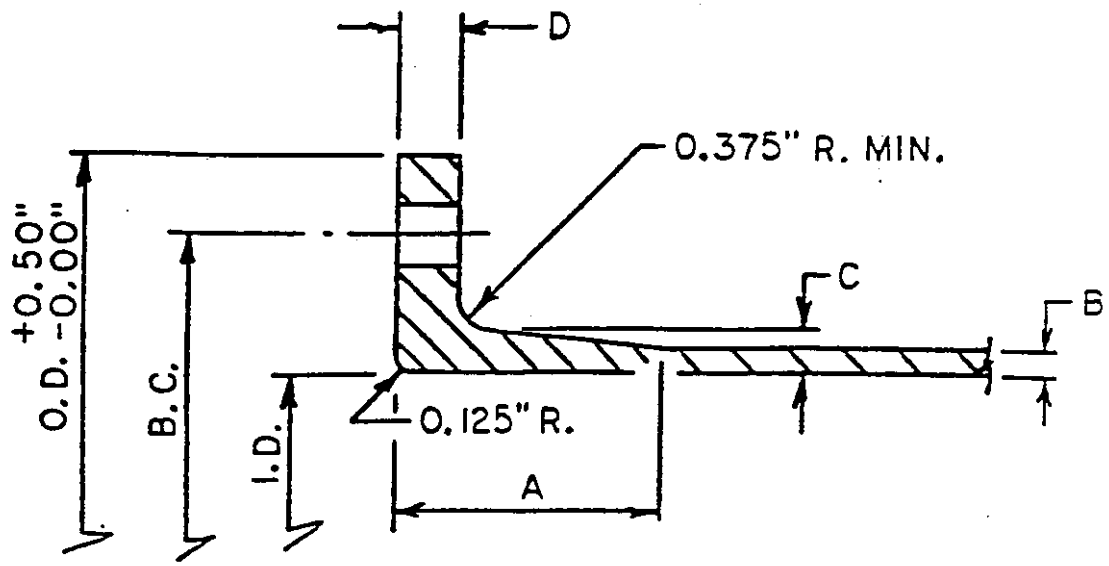


NOZZLE I.D.	NOZZLE O.D	BOLT CIRCLE	NO. OF BOLT HOLES	DIA. OF BOLT HOLES	A	B (table 2)	C	D
12"	16 3/8"	15"	12	1/2"	2"	0.30"	0.47"	0.50"
14"	18 3/8"	17"	12	1/2"	2"	0.30"	0.47"	0.50"
16"	20 3/8"	19"	16	1/2"	2 1/2"	0.30"	0.54"	0.63"
18"	22 3/8"	21"	16"	1/2"	2 1/2"	0.37"	0.60"	0.63"
20"	24 3/8"	23"	20	1/2"	2 1/2"	0.37"	0.60"	0.63"
24"	28 3/8"	27"	20	1/2"	2 1/2"	0.41"	0.60"	0.63"
30"	34 3/8"	33"	28	1/2"	2 1/2"	0.41"	0.63"	0.63"
36"	40 3/8"	39"	32	½"	2 ½"	0.48"	0.63"	0.63"
42"	46 3/8"	45"	36	½"	2 ½"	0.47"	0.75"	0.75"
48"	54 3/8"	52"	44	5/8"	3"	0.48"	0.75"	0.75"
54"	60 3/8"	58"	44	5/8"	4"	0.61"	1.00"	1.00"
60"	66 3/8"	64"	52	5/8"	4"	0.61"	1.00"	1.00"
72"X24"	80"X32"	***	***	***	4"	0.61"	1.00"	1.00"

*** To be designed by Contractor

FRP DRILLED FLANGE - DUCT DRILLING

DETAIL - 2

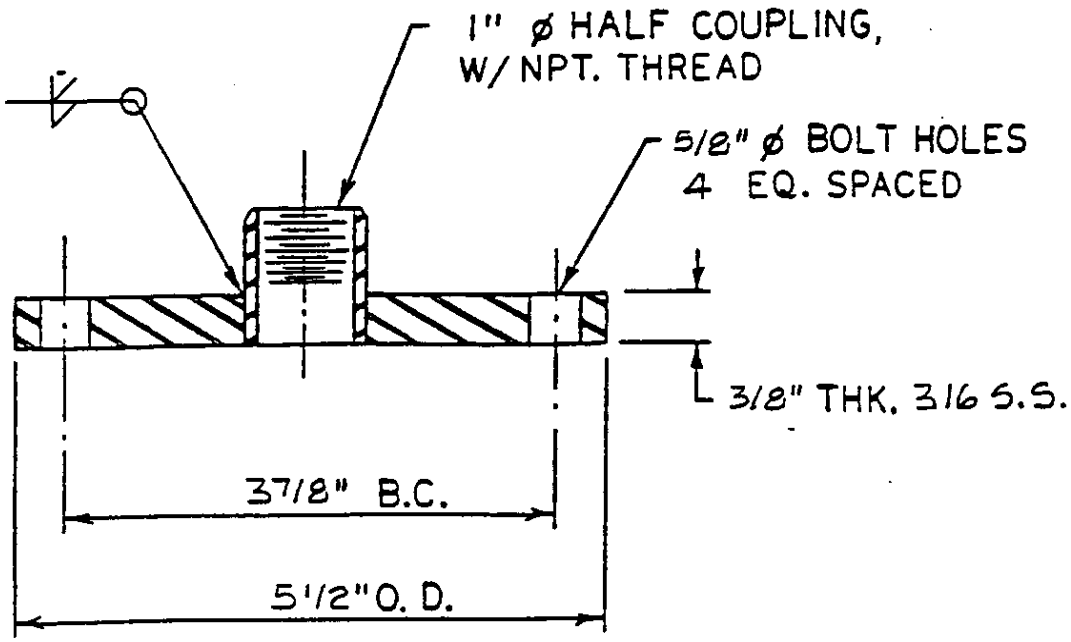


125/150 PATTERN

NOZZLE I.D.	O.D	B.C.	NO. OF BOLT HOLES	DIA. OF BOLT HOLES	A	B	C	D
1 ½"	5"	3 7/8"	4	5/8"	2"	0.22"	0.50"	0.50"

1 ½" FRP DRILLED FLANGE – FOR DUCT DRAIN

DETAIL - 3



1 ½" FLANGE

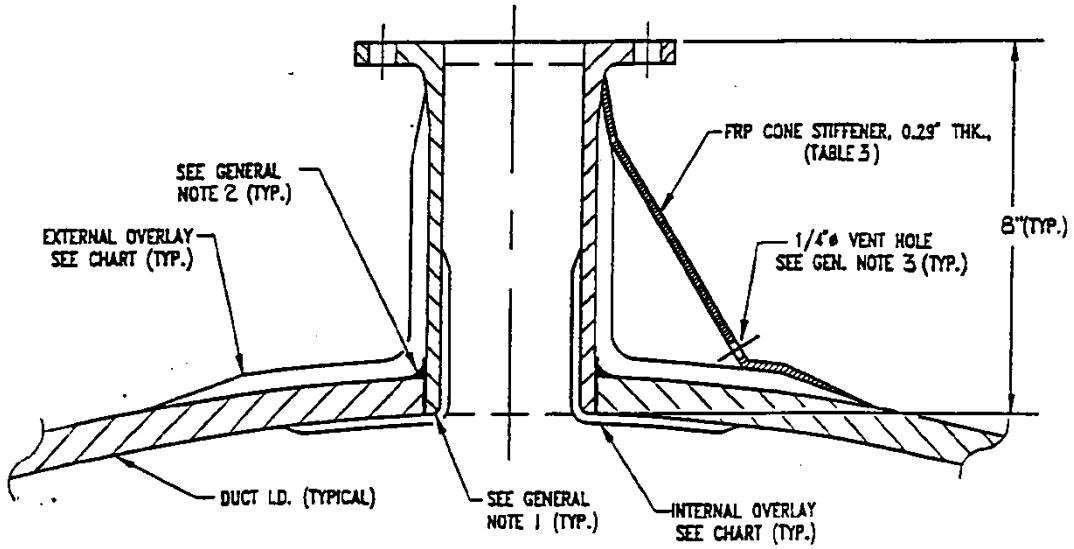
DUCT DRAIN AND PRESSURE INDICATOR ATTACHMENT FLANGE

DETAIL - 4

NOZZLE I.D.	NOZZLE O.D	BOLT CIRCLE	NO. OF BOLT HOLES	DIA. OF BOLT HOLES	A (table 2)
12"	16 3/8"	15"	12	1/2"	0.30"
14"	18 3/8"	17"	12	1/2"	0.30"
16"	20 3/8"	19"	16	1/2"	0.30"
18"	22 3/8"	21"	16"	1/2"	0.37"
20"	24 3/8"	23"	20	1/2"	0.37"
24"	28 3/8"	27"	20	1/2"	0.41"
30"	34 3/8"	33"	28	1/2"	0.41"
36”	40 3/8”	39”	32	½”	0.48”
42”	46 3/8”	45”	36	½”	0.47”
48”	54 3/8”	52”	44	5/8”	0.48”
54”	60 3/8”	58”	44	5/8”	0.61”
60”	66 3/8”	64”	52	5/8”	0.61”

BLIND FLANGES

DETAIL – 5



NOZZLE I.D.	EXTERNAL OVERLAY		INTERNAL OVERLAY	
	THK. (TABLE 3)	WIDTH (TABLE 5)	THK. (TABLE 4)	WIDTH. (TABLE 6)
1 1/2"	0.29"	10"	0.11"-(MMCC)"	4"

GENERAL NOTES:

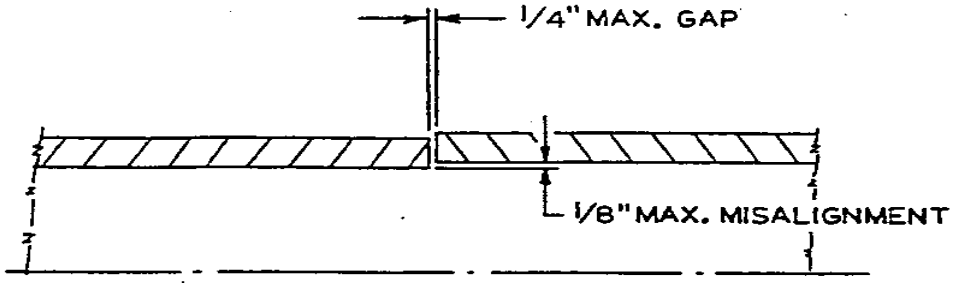
1. RADIUS INSIDE EDGE OF NOZZLE, IF INTERNAL OVERLAY IS APPLIED, 1/8" MIN. TO ¼" MAX. WHERE INTERNAL OVERLAY IS NOT POSSIBLE RESIN COAT EDGES AS SHOWN IN DETAIL-10 AND APPLY 0.30" THICK EXTERNAL OVERLAY.

2. FILL VOIDS WITH RESIN PUTTY. FLARE PUTTY INTO A RADIUS ¼" MIN. TO 3/8" MAX.

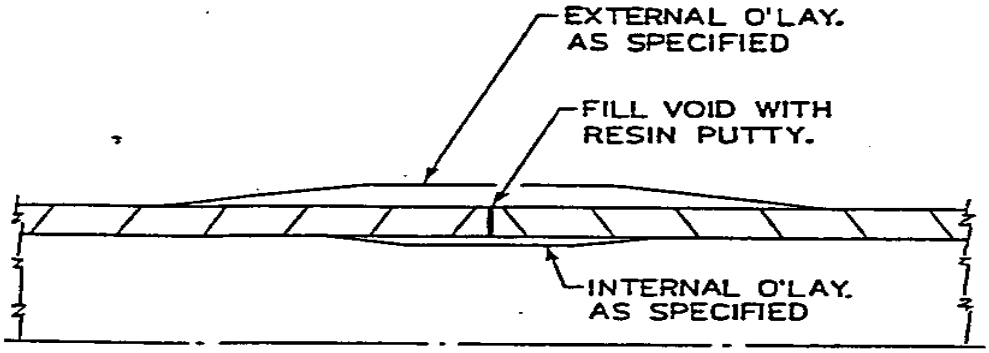
3. LOCATE VENT HOLE AS LOW AS POSSIBLE, RESIN COAT EDGE OF HOLE.

1 ½" DIA. DUCT DRAIN AND P.I. NOZZLE INSTALLATION

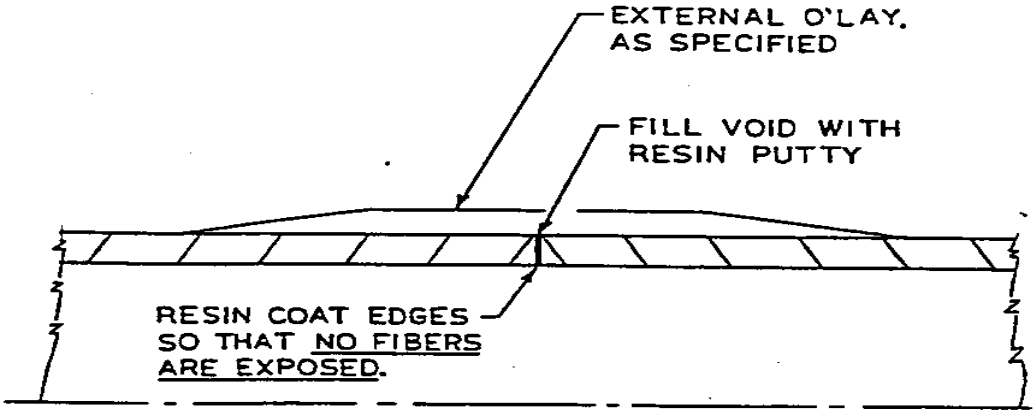
DETAIL - 6



JOINT TOLERANCE



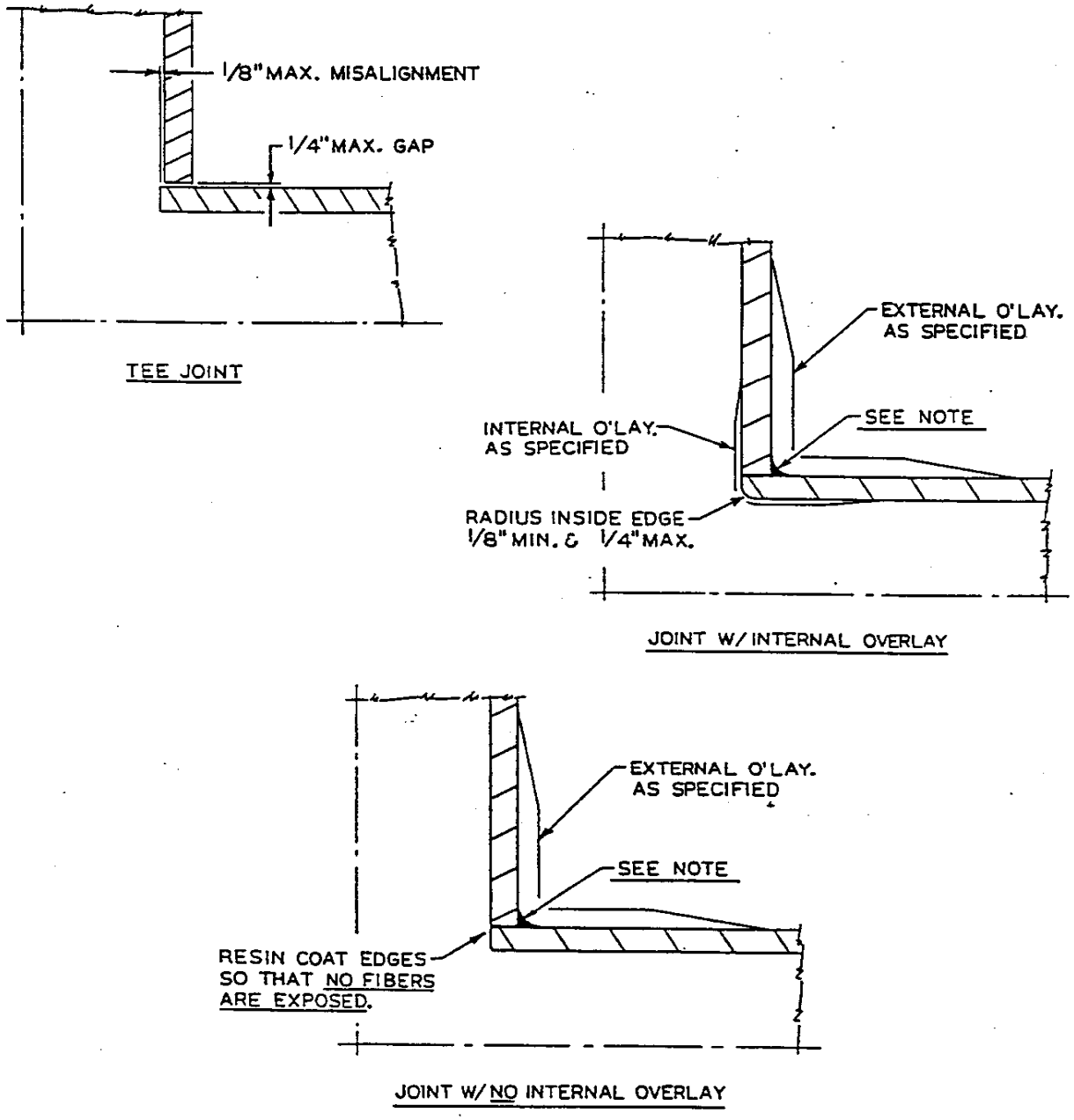
JOINT W/ INTERNAL OVERLAY



JOINT W/ NO INTERNAL OVERLAY

FRP BUTT JOINTS

DETAIL - 7

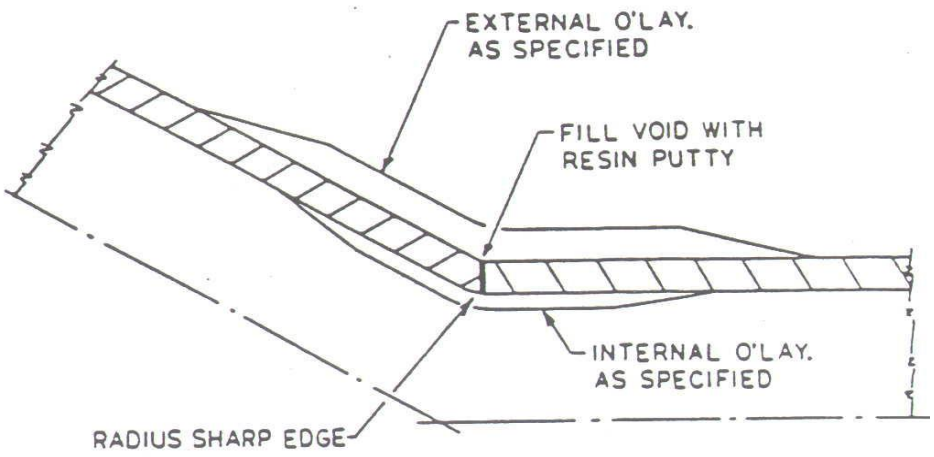


GENERAL NOTE:

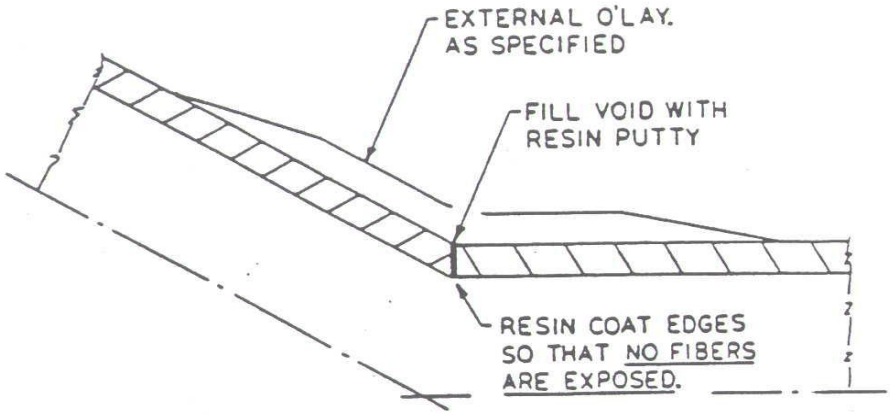
1. FILL VOIDS WITH RESIN PUTTY AS SHOWN. FLARE PUTTY INTO A RADIUS ¼" MIN. TO 3/8" MAX.

FRP TEE JOINTS

DETAIL – 8



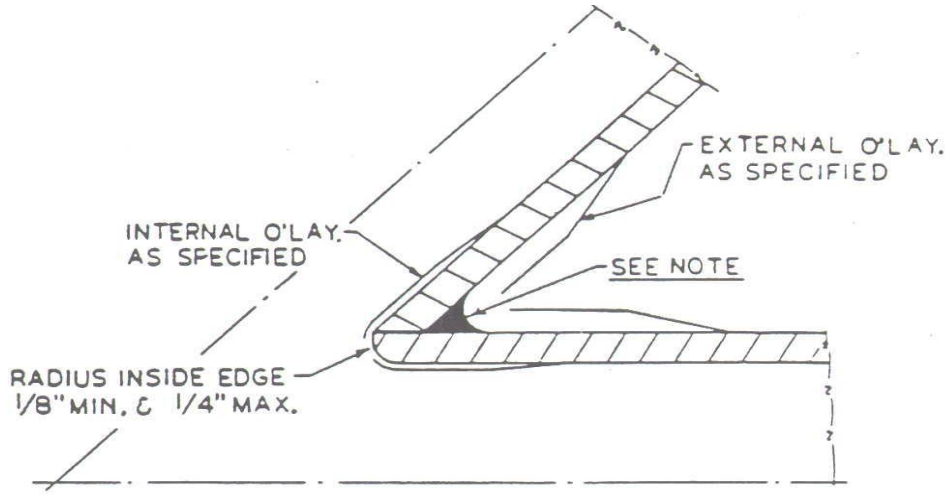
JOINT W/ INTERNAL OVERLAY



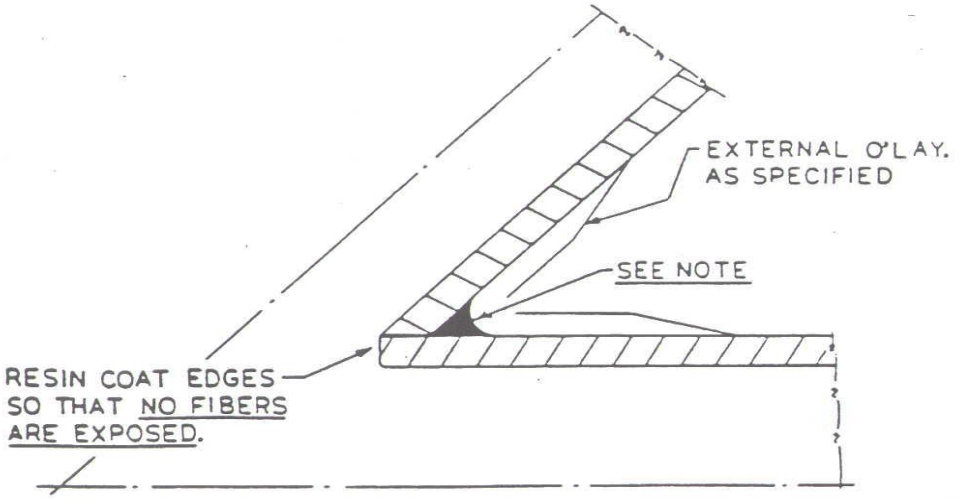
JOINT W/ NO INTERNAL OVERLAY

FRP MITER JOINTS

DETAIL - 9



JOINT W/ INTERNAL OVERLAY



JOINT W/ NO INTERNAL OVERLAY

GENERAL NOTE:

1. FILL VOIDS WITH RESIN PUTTY AS SHOWN, FLARE PUTTY INTO A RADIUS 3/8" MIN.AND ¾" MAX

FRP LATERAL JOINTS

DETAIL – 10

FRP DUCT BUTT JOINT OVERLAY		
DUCT I.D.	EXTERNAL OVERLAY (TABLE 2)	
	THK.	WIDTH
12"	0.30"	8"
14"	0.30"	8"
16"	0.30"	8"
18"	0.37"	10"
20”	0.37"	10"
24"	0.36"	10"
30"	0.36"	12"
36"	0.36"	14"
42"	0.36"	14"
48”	0.40”	14”
54”	0.47”	14”
60”	0.47”	16”
72”	0.47”	16”

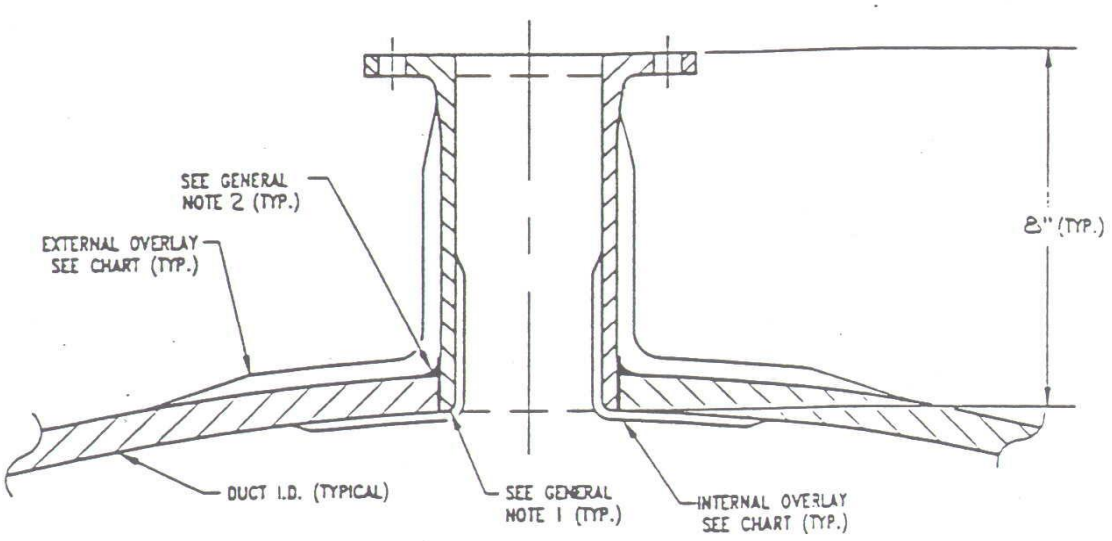
Note: For 24" Dia. And Larger, and where accessible apply an internal overlay (MMCCX6"wide)

FRP DUCT TEE JOINT OVERLAY		
DUCT	EXTERNAL OVERLAY (TABLE 2)	
I.D.	THK.	WIDTH
12"	0.30"	10"
14"	0.30"	10"
16"	0.30"	10"
18"	0.37"	12"
20"	0.37"	12"
24"	0.37"	12"
30"	0.37"	14"
36"	0.37"	14"
42"	0.4"	14"
48”	0.4”	16”
54”	0.4”	16”
60”	0.4”	16”

Note: For header diameter 24" and larger, and where accessible, apply an internal overlay (MMCCX6"wide)

FRP BUTT JOINTS AND TEE JOINTS CHARTS

DETAIL - 11



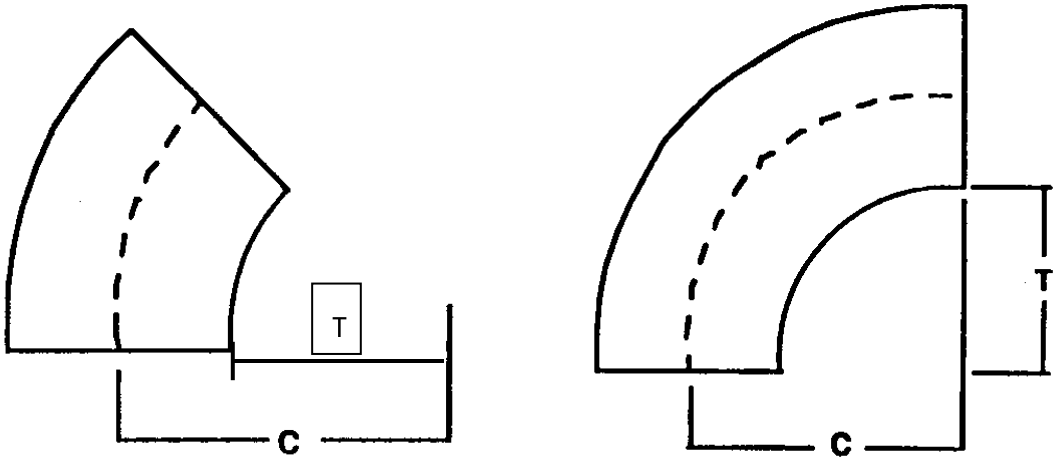
NOZZLE I.D.	EXTERNAL OVERLAY		INTERNAL OVERLAY	
	THK.	WIDTH	THK.	WIDTH
12”	0.36”	14”	0.11”	6”
14”	0.36”	14”	0.11”	6”
20”	0.36”	14”	0.11”	6”

GENERAL NOTES:

1. RADIUS INSIDE EDGE OF NOZZLE 1/8” MIN. TO 1/4” MAX.
2. FILL VOIDS WITH RESIN PUTTY, FLARE PUTTY INTO A RADIUS 1/4 MIN. TO 3/8” MAX.

DAMPER NOZZLE INSTALLATION

DETAIL – 12



DIAMETER	C	DIAMETER	C
4”	6”	22”	33”
5”	7 1/2”	24”	36”
6”	9”	26”	39”
7”	10 1/2”	28”	42”
8”	12”	30”	45”
9”	13 1/2”	32”	48”
10”	15”	36”	54”
12”	18”	42”	63”
14”	21”	48”	72”
16”	24”	54”	81”
18”	27”	60”	90”
20”	30”	70”	105”

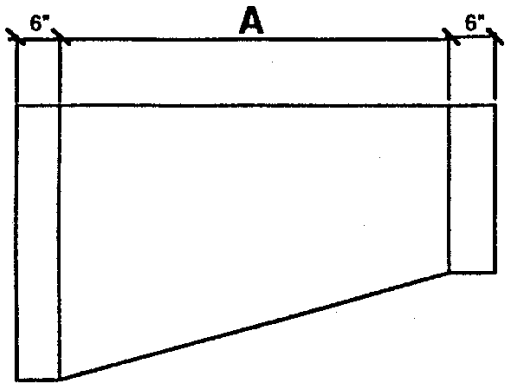
LONG RADIUS ELBOWS SHORT RADIUS ELBOWS
C = 1.5 x DIAMETER C = 1.0 x DIAMETER
T = 1.0 x DIAMETER T = 0.5 x DIAMETER

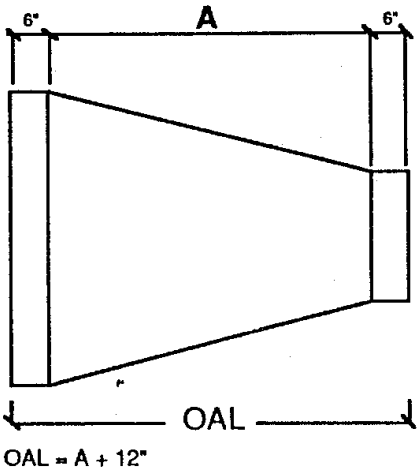
GENERAL NOTE:

1. ELBOWS 2” DIA. THROUGH 30” DIA ARE ONE (1) PIECE MOLDED SMOOTH RADIUS. 32”DIA AND LARGER ARE FIVE (5) PIECE MITERED 90 DEGREE ELBOWS AND 3 PIECE MITERED 45 DEGREE ELBOWS.

90 AND 45 DEGREE ELBOWS

DETAIL – 13





ECCENTRIC REDUCER

INCHES OF REDUCTION	A
1"	4 ¼"
2"	8"
3"	11 ¾"
4"	15 1/2"
5"	19 1/4"
6"	23"
7"	26 3/4"
8"	30 1/4"
9"	34"
10"	37 ¾"
11"	41 1/2"
12"	45 1/4"
13"	49"
14"	52 3/4"
15"	57 1/4"
16"	64"
17"	67 3/4"
18"	71 1/2"
19"	69 1/4"
20"	75 1/4"

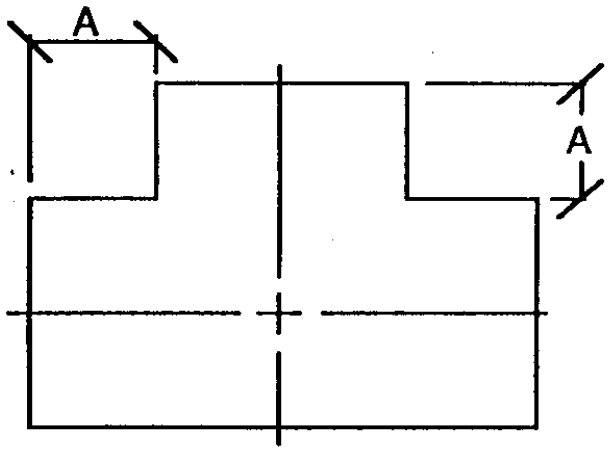
CONCENTRIC REDUCER

INCHES OF REDUCTION	A
1"	2 1/8"
2"	4"
3"	5 7/8"
4"	7 3/4"
5"	9 5/8"
6"	11 1/2"
7"	13 3/8"
8"	15 1/8"
9"	17"
10"	18 7/8"
11"	20 3/4"
12"	22 5/8"
13"	24 1/2"
14"	26 3/8"
15"	28 5/8"
16"	32"
17"	33 7/8"
18"	35 3/4"
19"	34 5/8"
20"	37 5/8"

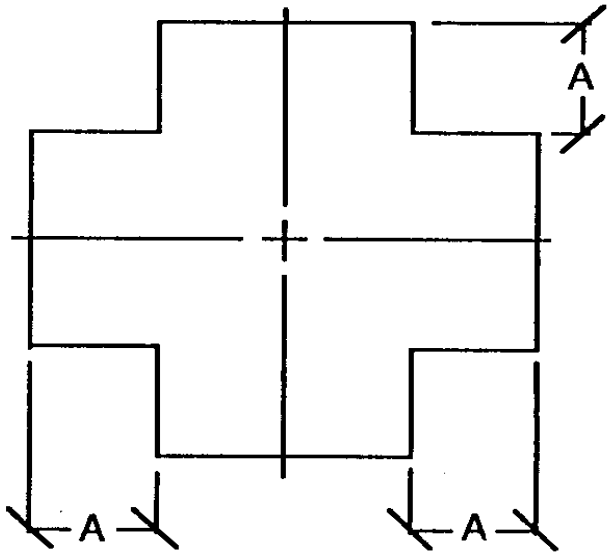
ECCENTRIC AND CONCENTRIC REDUCERS

DETAIL – 14

90° TEE



90° CROSS



FOR DIAMETERS 10" DIA AND SMALLER: A = 4" AND FOR DIAMETERS 12" DIA AND LARGER: A = 6"

90 DEGREE TEE AND CROSS

DETAIL - 15

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SECTION 23 37 00

AIR OUTLETS AND INLETS

PART 1 GENERAL

1.01 SUMMARY

A. Scope: This Section specifies provisions for the materials, installation, and testing of air outlets and inlets, including:
   1. Grilles, Registers, Diffusers
   2. Gravity Intake and Relief Hoods.

1.02 SUBMITTALS

A. Procedures: Section 01 33 00.

B. Action Submittal Items for this Section:
   1. Data Sheet: For each type of air outlet and inlet, and accessory furnished; indicate construction, finish, and mounting details.
   2. Performance Data: Include throw and drop, static-pressure drop, and noise ratings for each type of air outlet and inlet.
   3. Schedule of diffusers, registers, and grilles indicating drawing designation, room location, quantity, model number, size, and accessories furnished.
   4. Manufacturer's data for hoods, including materials of construction, construction details of equipment, weight of equipment, mounting, seismic bracing, and support. Also include information on the following:
      a. Drawings showing general dimensions and confirming the size of equipment
      b. Certified hood performance curves with system operating conditions indicated.
      c. Dampers, including housings, linkages, and operators.
      d. Roof curbs and accessories.
   5. Shop and field painting systems. Include manufacturer's descriptive technical catalog literature and specifications.
   6. Operation and Maintenance Information: Section 01 78 23.
   7. Samples, where required by the specification section.
   8. Rigid Equipment Mount Installation Checklist (Form 43 05 13-A).
   9. Installation Forms in accordance with Section 01 99 90.
   10. Testing Forms in accordance with Section 01 99 90.

C. Informational Submittal Items for this Section:
   1. Structural Design and Anchorage: Section 01 73 24.

PART 2 PRODUCTS

2.01 PERFORMANCE REQUIREMENTS

A. General Requirements: Section 23 00 00.

2.02 DIFFUSERS, GRILLES AND REGISTERS

A. General:

1. Except as specified otherwise, provide manufacturer's standard diffusers, grilles, and registers where shown on Drawings, of type, size, shape, and capacity specified, constructed of materials and components specified and as required for complete installation.
2. Performance: Furnished diffusers, grilles and registers shall each have, as minimum, performance (noise criteria ratings evidenced by listing in manufacturer's current data) as noted or scheduled on Drawings.
3. Compatibility: Border styles shall be compatible with adjacent wall, ceiling or duct systems, specifically manufactured to fit into ceiling module, wall or duct construction with accurate fit and adequate support. Refer to the Drawings and Specifications for types of ceiling, wall and duct systems that will contain respective type of diffuser, register, or grille.
4. All diffusers shall be made of material similar to the ductwork in which the damper is located. Aluminum construction is acceptable for installation in galvanized steel ductwork. Where aluminum construction is not available where aluminum ductwork is utilized, stainless steel shall be used. Where stainless steel construction is not available, aluminum construction with corrosion resistant applied coating may be used.
5. Provide 1-, 2-, 3-, or 4-way deflection as specified on Drawings.
6. Dampers: Where duct mounted volume control dampers are not accessible, diffusers shall be furnished with an opposed blade volume control dampers and gasket seals. Damper shall be adjustable through face of the diffuser or factory assembled side operator providing external duct operation. Construct of the same material as the grille. Manufacturer same as grilles/diffuser.
7. Diffusers in finished areas shall receive a white power coat finish. Where required on the Drawings, factory applied corrosion resistant coatings shall be provided.

B. Ceiling Supply Diffusers (CSD): Ceiling Supply Diffusers shall have air patterns and size as specified on the Drawings. For hung tile ceilings, frames shall be lay-in type. For hard ceilings, frame shall be flush mounting type. Where lights are surface mounted, diffusers shall be of dropped face design.

1. CSD-1: Rectangular square cone diffusers shall be adjustable type, Titus Model TMSA (steel)/TMSA-AA (aluminum); Price Model SCDA (steel)/ASCDA (aluminum); or Approved Equal.
2. CSD-2: Rectangular modular core type diffusers, Titus Model MCD (steel)/MCD-AA (Aluminum); Price Model SMCD (steel)/AMCD (aluminum); or Approved Equal. Provide rectangular to round adapter for connecting to round ductwork.
3. CSD-3: Round diffusers (for exposed duct in finished non-process areas) shall be adjustable type, Titus Model TMRA (steel)/TMRA-AA (aluminum); Price Model RCDA (steel)/ARCDA (aluminum); or Approved Equal.

C. Wall or Duct-Mounted Supply Grilles (WSG): Wall supply grilles and registers shall be adjustable louver or double deflection type. Supply grilles installed in wall openings shall have an overlap margin to cover wall opening.

1. WSG-1: Adjustable diffusers for rectangular ductwork shall be adjustable type, Titus Model 250 (steel)/250-AA (aluminum); Tuttle & Bailey Model A20, A40 (aluminum); or Approved Equal.
2. WSG-2: Double-deflection louvered type with individually adjustable bars that allow 45° adjustment spread. Bars shall be on 3/4-inch centers, with horizontal face bars and vertical rear bars. Titus Model 300RL (steel)/ 300 FL (aluminum)/300 RL-SS (stainless steel); Price Model 520 (steel)/ 610 (aluminum)/720 (stainless steel); or Approved Equal.

D. Ceiling Exhaust and Return Registers (CER) and Grilles (CEG): Ceiling exhaust or return air registers and grilles shall be of sizes specified on the Drawings.

1. CER-1: Grilles shall be eggcrate type, with a grid of 1/2-inch by 1/2-inch by 1/2-inch. Ceiling grilles shall have a factory applied prime coat and baked white enamel finish. For hung tile ceilings, frames shall be lay-in type. For hard ceilings, frame shall be flush mounted type. Grilles in plaster, drywall and concealed spline ceilings shall have an overlap margin to cover the ceiling opening. Ceiling grilles shall have an integral duct collar and concealed mounting frame. Duct at grille inlet/outlet shall be internally painted flat black. Titus Model 50R (steel)/50F (aluminum); Price Model 80 (aluminum); or Approved Equal.

E. Wall- or Duct-Mounted Exhaust or Return Air Grilles (WEG): Wall exhaust or return air grilles shall have sizes as specified on the Drawings. Grille blades shall be set horizontally and on 3/4-inch to 35-45 degrees unless otherwise noted.

1. WEG-1: Louvered return grilles for rectangular ductwork shall be Titus Model 350RL (steel)/ 350FL (aluminum)/355RL (stainless steel); Price Model 530 (steel)/630 (aluminum)/730 (stainless steel); or Approved Equal.
2. WEG-2: Grilles shall be eggcrate type, with a grid of 1/2-inch by 1/2-inch by 1/2-inch. Ceiling grilles shall have a factory applied prime coat and baked white enamel finish. For hung tile ceilings, frames shall be lay-in type. For hard ceilings and ducts, frame shall be flush mounted type. Grilles in plaster, drywall and concealed spline ceilings shall have an overlap margin to cover the ceiling opening. Ceiling grilles shall have an integral duct collar and concealed mounting frame. Duct at grille inlet/outlet shall be internally painted flat black. Titus Model 50R (steel)/50F (aluminum); Price Model 80 (aluminum); or Approved Equal.

F. Door Grilles:

1. Type: V-shaped louvers of 20 gauge thick steel, 1-inch deep on 1/2-inch centers.
2. Frame: 20 gauge steel with auxiliary frame to give finished appearance on both sides of door, with factory prime coat finish.
3. Manufacturers: Price; Titus; or Approved Equal.

2.03 GRAVITY VENTILATION HOODS

A. Intake and relief hoods shall be constructed of heavy gauge aluminum and of precision formed, arched panels with interlocking seams. Unit shall be equipped with a ½-inch aluminum bird screen mounted across the discharge area of the hood, gravity backdraft damper tray and roof curb. Where specified, hoods shall be coated with a Heresite applied in strict conformance with the paint manufacturer's instructions. Hood shall have throat size as specified on the Drawings.
   1. Rectangular intake and relief hoods shall be Greenheck Model FGI/FGR; Loren Cook Model GI/GR; or Approved Equal.
   2. Round intake and relief Hoods shall be Greenheck Model GRSI/GRSR; Loren Cook Model PR or TR; or Approved Equal.

B. See the Ventilation Hood Schedule on the Drawings for specific requirements.

PART 3 EXECUTION

3.01 INSTALLATION

A. General Requirements: Section 23 00 00.

B. Equipment Mounting:
   1. Procedures: Section 43 05 13.
   2. Install the applicable Equipment Mounting Systems in accordance with the Equipment Mounting Schedule specified in Section 43 05 13.

C. Ventilation Hoods:
   1. Install in accordance with manufacturer's instructions.
   2. Install ventilation hoods level and plumb.
   3. Hoods used for exhaust of moist air are to be constructed of aluminum construction and be warranted for their application in moist conditions.
   4. Install floor-mounting units on concrete bases designed to withstand, without damage to equipment, the seismic force required by code.
   5. Secure ventilation hoods to roof curbs with cadmium-plated hardware.
   6. In seismic zones, restrain support units.
   7. Install units with clearances for service and maintenance.
   8. Duct installation and connection requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of ducts and duct accessories. Make final duct connections with flexible connectors per Section 23 30 00.

D. Diffusers, Grilles and Registers:
   1. Install in accordance with manufacturer's instructions. Provide seismic supports, clips, and bracing per local code. Coordinate installation of framing. Provide complete coverage of rough openings by integral device flanges or auxiliary frames. Where above ceiling location is unconditioned space, caulk rough openings; repair and re-paint locations where dust entrainment streaks develop due to unsealed openings.

2. Damp locations, such as lockers, restrooms, showers, natatoriums, whirlpool/spas, to have aluminum construction even if scheduled otherwise; mounting hardware to be stainless steel.
3. Check location of outlets and inlets and make necessary adjustments in position to conform to architectural features, symmetry, and lighting arrangement. Coordinate with architectural reflected ceiling plan(s); reflected ceiling plans determine final locations.
4. Install diffusers to ductwork with air tight connection. 18-inch straight duct section or acoustic plenum at connection. Provide square to round adapters where required for connection to round ducts.
5. Provide integral balancing dampers for diffusers, and grilles and registers where duct manual balancing dampers are not shown or specified.
6. Adjust discharge direction and spread per plans. Adjust throws of air outlets to eliminate drafts and to distribute air during heating and cooling operation.
7. Exterior color of grilles per Owner. White finish if not otherwise scheduled or noted by Owner. Paint ductwork visible behind air outlets and inlets matte black.
8. Ceiling Membrane: Protect ceiling membrane per code. Fire caulk around openings.

3.02 COATINGS

A. Coating Procedures: Section 09 90 00.

B. Primer Coating: Shop apply in accordance with Section 09 90 00.

C. Finish Coating: Field apply in accordance with Section 09 90 00.

3.03 CLEANING

A. After completion of ductwork installation, operate each fan system (excluding exhaust fans) for a minimum of 30 minutes prior to installation of ceiling grilles and diffusers. After grilles and diffusers are installed, clean out accumulation of particles from grilles and diffusers prior to acceptance.

B. After installation of diffusers, registers, and grilles, inspect exposed finish. Clean exposed surfaces to remove burrs, dirt, and smudges. Replace diffusers, registers, and grilles that have damaged finishes.

END OF SECTION

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SECTION 26 05 00

COMMON WORK RESULTS FOR ELECTRICAL

PART 1 GENERAL

1.01 DESCRIPTION

A. Scope:

1. This section specifies general requirements for electrical work. Detailed requirements for specific electrical items are specified in other sections but are subject to the general requirements of this section.

B. Definitions:

1. Schematic or Elementary Diagram:
   a. A schematic (elementary) diagram shows, by means of graphic symbols, the electrical connections and functions of a specific circuit arrangement. The schematic diagram facilitates tracing the circuit and its functions without regard to the actual physical size, shape, or location of the component devices or parts.
2. One-Line Diagram:
   a. A one-line diagram shows by means of single lines and graphical symbols the course of an electrical circuit or system of circuits and the components, devices or parts used therein. Physical relationships are usually disregarded.
3. Block Diagram:
   a. A block diagram is a diagram of a system, instrument, computer, or program in which selected portions are represented by annotated boxes and interconnecting lines.
4. Wiring Diagram or Connection Diagram:
   a. A wiring or connection diagram includes all of the devices in a system and shows their physical relationship to each other including terminals and interconnecting wiring in an assembly. This diagram shall be (a) in a form showing interconnecting wiring only by terminal designation (wireless diagram), or (b) a panel layout diagram showing the physical location of devices plus the elementary diagram.
5. Interconnection Diagram:
   a. Interconnection diagrams shall show all external connections between terminals of equipment and outside points, such as motors and auxiliary devices. References shall be shown to all connection diagrams which interface to the interconnection diagrams. Interconnection diagrams shall be of the continuous line type. Bundled wires shall be shown as a single line with the direction of entry/exit of the individual wires clearly shown. Wireless diagrams and wire lists are not acceptable.
      1) Each wire identification as actually installed shall be shown. The wire identification for each end of the same wire shall be identical. All devices and equipment shall be identified. Terminal blocks shall be shown as actually installed and identified in the equipment complete with individual terminal identification.

2) All jumpers, shielding and grounding termination details not shown on the equipment connection diagrams shall be shown on the interconnection diagrams. Wires or jumpers shown on the equipment connection diagrams shall not be shown again on the interconnection diagram. Signal and DC circuit polarities and wire pairs shall be shown. Spare wires and cables shall be shown.

6. Arrangement, Layout, or Outline Drawings:
   a. An arrangement, layout, or outline drawing is one which shows the physical space and mounting requirements of a piece of equipment. It may also indicate ventilation requirements and space provided for connections or the location to which connections are to be made.

1.02 REFERENCES

A. General:
   1. This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.
   2. Unless otherwise specified, references to documents shall mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid (or on the effective date of the Agreement if there were no Bids). If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued. Where document dates are given in the following listing, references to those documents shall mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, discontinued or replaced.

B. NECA 1 - Standard for Good Workmanship in Electrical Construction

C. NFPA 70 – National Electrical Code (NEC)

D. NFPA 70E – Standard for Electrical Safety in the Workplace

E. ANSI C2 – National Electrical Safety Code (NESC)

1.03 SUBMITTALS

A. Procedures: in accordance with Section 01 33 00.

B. Closeout Submittals:
   1. Operations and Maintenance Data:
      a. As specified in Section 01 78 23.

b. Provide operation and maintenance information at the time of equipment, device, or material site delivery, or at a certain stage of project completion as required by Section 01 78 23, whichever is the earlier.

2. Record documents:
   a. As specified in Section 01 78 39.

1.04 QUALITY ASSURANCE

A. Identification of Listed Products:
   1. Provide electrical equipment and materials listed by a nationally recognized testing laboratory (NRTL) for the purpose for which they are to be used. Potential NRTLs include Underwriters Laboratories (UL), Canadian Standards Association (CSA), and Intertek Electrical Testing Laboratories (ETL). NRTL shall be acceptable to the inspection authority having jurisdiction.
   2. When a product is not available with a testing laboratory listing for the purpose for which it is to serve, the product may be required to undergo inspection at the manufacturer's place of assembly, with certified test reports delivered to or in person witness testing by the AHJ. All costs and expenses incurred for such inspections shall be included in the original base contract price.

B. Factory Tests:
   1. Where specified in the individual product specification section, perform factory tests at the place of fabrication and performed on completion of manufacture or assembly. Include the costs of factory tests in the original base contract price.

1.05 SITE CONDITIONS

A. Ambient Conditions:
   1. Design, furnish, and install electrical equipment, materials for the ambient conditions specified in Section 01 11 80, including sizing and derating equipment as required to provide the specified ratings and capacities under the project ambient conditions.

A. Electrical enclosures, raceways, and supports:
   1. Provide electrical enclosures, boxes, panels, wireways, raceways, fittings, hangers, supports, and all related components in accordance with the table below, except where noted otherwise in equipment specifications:

TABLE A

Location	Electrical Enclosure Rating	Exposed Raceway Type	Flexible Raceways for Final Connections	Hangers and Supports
Indoors: Architecturally Finished Area	NEMA 12: Steel	EMT	FMC	Steel: Electro-galvanized
Indoors: Electrical Room	NEMA 12: Steel	GRS	LFMC	Steel: HDGAF
Indoors: Process Area	NEMA 4X: 316SS	**[PGRS] [RGS]**	LFMC	316SS
Corrosive Area	NEMA 4X: 316SS	PGRS	LFMC	316SS
Corrosive Area (Hypochlorite)	NEMA 4X: FRP	PVC80 or RTRC	LFNC	FRP

Location	Electrical Enclosure Rating	Exposed Raceway Type	Flexible Raceways for Final Connections	Hangers and Supports
Corrosive Area (Polymer)	NEMA 4X: 316SS	PGRS	LFMC	316SS
Hazardous area	NEMA 7	PGRS	LFMC	316SS

Refer to Section 26 05 33 for raceway specifications.

HDGAF = Hot Dip Galvanized After Fabrication

1.06 DELIVERY, STORAGE, AND HANDLING

A. As specified in Section 01 66 00.

PART 2 PRODUCTS

2.01 EQUIPMENT AND MATERIALS

A. General:
   1. Provide equipment and materials new and free from defects. Provide all material and equipment of the same or a similar type from the same manufacturer throughout the work. Use standard production materials wherever possible.

2.02 FINISHES:

A. Provide equipment manufacturer's standard finish/coatings for the enclosure type and equipment standards referenced in the equipment specifications (IEEE, ANSI, NEMA, etc.).

B. Where referenced standards do not provide finish/coatings requirements, provide finish/coatings in accordance with section 09 90 00.

2.03 NAMEPLATES

A. Provide nameplates for all enclosures containing electrical equipment, including the following information:
   1. Unique identifier matching the Contract Drawings (e.g. LCP-2200)
   2. Functional description of equipment served (e.g. Bar Screen 2)
   3. Upstream disconnecting means / source of power (e.g. "SOURCE: LP-15 CKT 23")

B. Provide nameplates for all boxes (including pull, junction, and terminal boxes), including the following information:
   1. Unique identifier matching the Contract Drawings
      a. Where no identifier is present on the Drawings, assign a unique identifier that relates to the tags assigned to upstream conduits.
      b. Maximum operating voltage of conductors contained in the box (e.g. 480VAC, 120VAC, 24VDC, SIGNAL, NETWORK, or FIBER)

C. Nameplates shall be made from laminated phenolic plastic.
   1. Black backgrounds with 3/16-inch white letters.

2. Fastened using self-tapping stainless-steel screws. Nameplate adhesives will not be permitted on the outside of enclosures.
3. Submit abbreviations due to space limitations to Owner prior to manufacture.

PART 3 EXECUTION

3.01 INSTALLATION

A. General:
   1. Perform all work in accordance with NFPA 70 and all codes adopted by the Authority Having Jurisdiction (AHJ).
   2. Refer to the National Electrical Contractors Association's (NECA) National Electrical Installation Standards (NEIS) for Standard Practices for Good Workmanship in Electrical Contracting (NECA-1) as a minimum baseline of quality and workmanship for installing electrical products and systems that defines what is meant by "professional and skillful" as required by the National Electrical Code. Specified requirements supersede NECA practices.
   3. Install equipment in accordance with the manufacturer's installation instructions.
   4. Electrical drawings are diagrammatic and do not specify exact locations of equipment or equipment terminations, unless otherwise detailed or dimensioned. Coordinate the routing and location of electrical material or equipment with the work.
      a. Minor changes in location of electrical equipment or material or equipment made prior to installation shall be made at no cost to the Owner.
   5. Overcurrent protection and motor controller sizes and ratings shown in the Drawings, Schedules, and Specifications are based on preliminary estimated information from one or more potential equipment suppliers. Adjust the size and rating of overcurrent protective devices, motor controllers, and associated cables and raceways to conform to the requirements of the connected equipment actually provided.
      a. Adjustments to electrical overcurrent protection, cable, or raceway sizes to conform to the requirements of equipment provided under other Sections shall be made at no cost to the Owner.

B. Electrical Equipment Labeling:
   1. Arc-Flash Hazard Warning: provide electrical equipment with field marked signs and labeling to warn qualified persons of the potential electric arc flash hazards per NEC Article 110.16.
   2. Arc-Flash Hazard Labels: Provide electrical equipment with NFPA 70E labels installed stating the results of the arc flash analysis specified in Section 26 05 73.

3.02 FIELD QUALITY CONTROL

A. Provide testing in accordance with Section 26 08 00

3.03 SYSTEMS STARTUP

A. Provide commissioning in accordance with Section 01 91 00.

3.04 CLEANING

A. Vacuum and wipe down the interior and all surfaces of electrical equipment to remove dust and debris prior to testing and energization. Maintain cleanliness of equipment through final completion.

B. Touch up any damaged coatings or finishes on equipment as specified in Section 09 90 00 Special Requirements before final acceptance.

3.05 CLOSEOUT ACTIVITIES

A. Record Documents: maintain and annotate contract documents and during construction, including the record drawings and the following additional schedules, lists, and drawings:
   1. Interconnection Diagrams (Section 26 05 00)
   2. Original Submittal Drawings (Section 01 33 00)

END OF SECTION

SECTION 26 05 19

LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

PART 1 GENERAL

1.01 DESCRIPTION

A. This section specifies stranded copper cables, conductors, and wire used for power, lighting, analog, digital, pulse, or network signals and control circuits.

1.02 REFERENCES

A. General:
   1. This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.
   2. Unless otherwise specified, references to documents shall mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid (or on the effective date of the Agreement if there were no Bids). If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued. Where document dates are given in the following listing, references to those documents shall mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, discontinued or replaced.

B. ASTM B3 – Soft or Annealed Copper Wire

C. ASTM B8 – Concentric-Lay Stranded Copper Conductors, Hard, Medium-Hard, or Soft

D. ASTM B33 – Tinned Soft or Annealed Copper Wire for Electrical Purposes

E. ICEA S-86-516 – Ethylene Propylene Rubber Insulated Wire

F. NECA 1 – Good Workmanship in Electrical Construction

G. NECA 120 – Standard for Installing Armored Cable (AC) and Metal-Clad Cable

H. NEMA WC7 – Cross-linked Thermosetting Insulated Wire and Cable for The Transmission and Distribution of Electric Energy

I. NFPA 70 – National Electrical Code

J. UL 44 – Rubber Insulated Wires and Cables

K. UL 83 – Thermoplastic Insulated Wires and Cables

L. UL 486A-486B – Wire Connectors

M. UL 486C – Splicing Wire Connectors

1.03 SUBMITTALS

A. Procedures: in accordance with Section 01 33 00.

B. Informational Submittals:
   1. Manufacturer's cutsheets for each cable, conductor, splice, and termination type.

PART 2 PRODUCTS

2.01 CONDUCTORS AND CABLES

A. General:
   1. Application of Cable Types:
      a. Provide conductor and cable types according to the Schedules and Drawings.
      b. Where conductor or cable types are not shown on the Schedules or Drawings, provide cable types suitable for the application as identified by the "Uses Permitted" listed under each cable type in this Section and in accordance with NFPA 70.
      c. Power and control conductors and cable:
         1) Single Conductor:
            a) Provide minimum conductor size of 12 AWG for power and lighting circuits and minimum conductor size of 14 AWG for control circuits.
         2) Multiconductor Cable:
            a) Provide multiconductor power and control cable where identified on the drawings.
   2. Color Coding:
      a. Power Conductors:
         1) Power conductors shall have the following colors for the indicated voltage:

Power Conductor	480V	208/120V
Phase A	Brown	Black
Phase B	Orange	Red
Phase C	Yellow	Blue
Ground	Green	Green
Neutral	Gray	White

         2) Cables may be black with colored 3/4-inch vinyl plastic tape applied at each cable termination and in pull boxes, handholes and manholes. Tape shall be wrapped with 25 percent overlay to provide 3 inches minimum coverage.

b. Control Conductors:
   1) Single-conductor control conductors shall have the following colors for the indicated voltage:

Control Conductor	120V
Power (AC)	Black
Control (AC)	Red
Neutral	White
Ground	Green
Foreign Voltage (DC)	Blue/White
Foreign Voltage (AC)	Yellow
Power (DC)	Blue
Control (DC)	Violet
Intrinsically Safe	Light Blue

c. Signal Conductors:
   1) Signal cable conductors shall be color coded black and white for pairs or black, white, and red for triads. Each conductor and each group of conductors shall be numbered.

B. XHHW-2:
   3. Description:
      a. Industrial grade single conductor
      b. Sizes: 14 AWG through 750 kcmil as shown
   4. Voltage:
      a. 600 volts
   5. Conductor Material:
      a. Bare annealed copper
      b. Stranded per ASTM B8
         1) Solid conductors may be used for termination of 15A or 20A receptacle and lighting circuits only.
   6. Insulation:
      a. NEC Type XHHW-2; 90 degree C dry and C wet;
      b. Cross-Linked Polyethylene (XLP) per ANSI/NEMA WC70 ICEA S-95-658 and UL-44;
   7. Jacket:
      a. None
   8. Flame Resistance:
      a. Not applicable
   9. Manufacturer(s):
      a. General Cable
      b. Okonite
      c. Southwire
      d. Approved equal

10. Uses Permitted:
    a. Power, control, lighting and outlet circuits in raceways.

B. THWN-2:
1. Description:
    a. Single conductor lighting and receptacle type; Indoor branch circuit conductor.
2. Voltage:
    a. 600 volts
3. Conductor Material:
    a. Bare annealed copper
    b. Stranded per ASTM B8
        1) Solid conductors may be used for termination of 15A or 20A receptacle and lighting circuits only.
4. Insulation:
    a. THWN/THHN, 90 degree C dry, 75 degree C wet,Polyvinyl Chloride (PVC) per UL 83.
5. Jacket:
    a. Nylon
6. Flame Resistance:
    a. UL 83
7. Manufacturer(s):
    a. General Cable
    b. Okonite
    c. Southwire
    d. Approved Equal
8. Uses Permitted:
    a. Lighting, receptacle, and appliance circuits in raceways.

C. RHW-2:
1. Description:
    a. Single conductor power and control cable; Single Conductor 1/0 AWG - Cable Tray rated. Sizes: 14 AWG through 1000 kcmil as shown
2. Voltage:
    a. 600 volts
3. Conductor Material:
    a. Bare annealed copper; Class-B stranded per ASTM B8
4. Insulation:
    a. RHW-2 75 degree C wet; RHH 90 degree C dry; Composite of ethylene propylene rubber (EPR) per ICEA, UL 44 and NEMA WC-7.
5. Jacket:
    a. Chlorosulfonated polyethylene; Trade Name Example: Hypalon
6. Flame Resistance:
    a. IEEE 383 & 1202: 70,000 BTU per hour

7. Manufacturer(s):
    a. General Cable
    b. Okonite
    c. Southwire
    d. Approved Equal
8. Uses Permitted:
    a. Power, control, lighting and outlet circuits in raceways.

D. MXLPE/PVC
1. Description:
    a. Multiconductor Power or Control Cable
2. Cable Configuration:
    a. Individually insulated conductors bundled in an overall protetive cable jacket.
    b. Size and quantiy of conductors as indicated on the Schedules or Drawings. Insulated ground conductor in all cables.
    c. Type TC-ER (Tray Cable – Extended Run)
    d. Conductor Identification:
        1) Sizes #14-10: ICEA Method 1 or 2 (integral color coding in conductor insulation)
        2) Sizes >= #8: ICEA Method 4 (numbers printed on each conductor)
3. Voltage:
    a. 600 volts
4. Conductor Material:
    a. Bare annealed copper; Class-B stranded per ASTM B8
5. Voltage:
    a. 600 volts
6. Conductor Material:
    a. Bare annealed copper; stranded per ASTM B8, coated per ASTM B33
7. Conductor Insulation:
    a. NEC Type XHHW-2; 90 degree C dry and C wet;
    b. Cross-Linked Polyethylene (XLP) per ANSI/NEMA WC70 ICEA S-95-658 and UL-44
8. Cable Jacket:
    a. PVC
9. Manufacturer(s):
    a. General Cable 4500 /4550
    b. Okonite X-Olene-Okoseal
    c. Southwire 45052
10. Uses Permitted:
    a. Power, control, lighting and outlet circuits in raceway or cable tray.

E. VFD (MXLPE/S/PVC)
1. Description:
    a. Flexible Motor Supply Shielded Cable

2. Cable Configuration:
    a. Multi-conductor shielded motor feeder cable with PVC jacket:
        1) 3/C cable conductor minimum size is #12-AWG with grounding conductor.
3. Voltage:
    a. 1000 volts
4. Conductors:
    a. Phase Conductors:
        1) Material: Copper, stranded
        2) Insulation:
            a) Thermoset Crosslinked Polyethylene (XLPE):
                (1) 90 degree C dry, 75 degree C wet, per UL 44.
    b. Ground Conductors:
        1) (3) Symmetrical ground conductors sized in accordance with NEC 250.122
        2) Material: Copper, stranded
5. Jacket:
    a. PVC over assembly; jacket thickness per UL 1277 Cable Tray rated UL 1277 Type TC
6. Shield:
    a. Copper tape shield with minimum 25 percent overlap or longitudinal corrugated copper tape shield.
7. Flame Resistance:
    a. IEEE 383 Fire Test (70,000 BTU)
    b. IEEE 1202: Limited Smoke rated and labeled on cable jacket
    c. UL 1685: Vertical Tray Flame Exposure Test
8. Manufacturer(s):
    a. Belden 295XX series
    b. Lapp Cable:
        1) 1AWG - 500kcmil: OLFLEX VFD Symmetrical; or
        2) 1AWG – 350kcmil OLFLEX Servo 2YSLCY-JB flexible cable
    c. Okonite X-Olene Okoseal Shielded VFD
    d. Southwire Spec 45451
9. Execution:
    a. Installation:
        1) Install in conduit or cable tray. Not to be used for open wiring installation. Ground shields at both ends. Shield terminating gland may be used at the motor to ensure grounding the shield.
10. Uses permitted:
    a. Power circuits between variable frequency drives and motors, in raceway or cable tray.

F. MIC (Multiple Instrumentation Cable)
   1. Description:
      a. Multiple twisted, shielded pairs, 18 or 16 AWG, with overall shield instrumentation cable; Number of pairs as shown; UL listed, Cable Tray rated.
   2. Voltage:
      a. 600 volts
   3. Conductor Material:
      a. Bare annealed copper; Class-B stranded per ASTM B-8
   4. Insulation:
      a. 15 mil, Polyvinyl Chloride (PVC) with 4 mil nylon, 90 degree C temperature rated Color Code per ICEA Method-1: Pairs- Black and White with one conductor in each pair printed alpha-numerically for identification
   5. Lay:
      a. Twisted on a 2-inch lay
   6. Shield:
      a. 100 percent, 1.35 mil aluminum/polyester or mylar tape with 7-strand tinned copper drain wire
   7. Overall Shield:
      a. 2.35 mil aluminum-Mylar tape with 7-strand tinned copper drain wire
   8. Jacket:
      a. Flame-retardant, moisture and sunlight resistant 45 mil Polyvinyl Chloride (PVC)
   9. Flame Resistance:
      a. IEEE 1202
   10. Manufacturer(s):
      a. Belden 1048A/1049A/1055A/1039A, General Cable 2150, Okonite SP-OS, Southwire 43604/43608, approved equal
   11. Uses Permitted:
      a. Instrumentation signal circuits in raceway or cable tray.

2.02 COMPONENTS

A. Terminations:
   1. Terminations shall be listed to UL486A-486B for the application and conductor material.
   2. Lugs shall be compression type, made with a compression tool die approved for the purpose. Connectors shall be tin-plated high conductivity copper.
      a. Terminations for wire sizes No. 8 AWG and larger shall be compression tool installed one-hole lugs up to size No. 3/0 AWG, and two-hole or four-hole lugs for size No. 4/0 and larger. Mechanical clamp, dimple, screw-type connectors are not acceptable.
   3. Signal and control conductors shall be connected to terminal blocks.
   4. Motor connection kits shall consist of heat-shrinkable, polymeric insulating material over the connection area and high dielectric strength mastic to seal the ends against ingress of moisture and contamination. Motor connections may use the Tyco Electronics removable boot product line.

5. Motor connection kits shall accommodate a range of cable sizes for both in-line and stub-type configurations. Connection kits shall be independent of cable manufacturer's tolerances. Refer to the electric motor specification Section 43 05 21.
6. MC-HL Cable Terminations: Provide explosionproof, dustproof, connectors with epoxy sealing compound that provide a watertight mechanical seal and continuity of cable armor. Eaton TMCX, Appleton TMCX, or equal.

B. Splices:
1. Splices shall be listed to UL 486C for the application and conductor material.
2. In-line splices and taps for circuits other than lighting and receptacles shall be used only by written consent of the Owner.
3. Splices shall be compression type, made with a compression tool die approved for the purpose. Connectors shall be tin-plated high conductivity copper.
4. Splices shall be covered with electrical products designed for the application, insulated, and covered with a heat-shrinkable sleeve or boot.
5. Twist-on (wire nut) connectors may be used for lighting and receptacle circuits only.

C. Cord Grips:
1. Provide where indicated on the Drawings to attach flexible cord to equipment enclosures. Cord grips shall consist of a threaded aluminum body and compression nut with a neoprene bushing and stainless steel wire mesh for strain relief. Cord grip shall provide a watertight seal at enclosure interface and sized to accommodate the flexible cord.

PART 3 EXECUTION

3.01 INSTALLATION

A. General:
1. Install conductors, cables, terminations, and splices in accordance with NECA 1 and the manufacturer’s recommendations.
2. Raceway construction shall be complete, cleaned, and protected from the weather before cable is installed. Where wire or cable exits a raceway, a wire or cable support shall be provided.
3. Pulling wire and cable into conduit or trays shall be completed without damaging or putting undue stress on the insulation or jacket. Manufacturer recommended and UL Listed pulling compounds are acceptable lubricants for pulling wire and cable. Grease is not acceptable.
4. Raceway fill limitations shall be as defined by NEC and the following:
a. Lighting and receptacle circuits may be in the same conduit in accordance with de-rating requirements of the NEC. Lighting and receptacle circuits shall not be in conduits with power or control conductors. Signal conductors shall be in separate conduits from power and control conductors. Motor feeder circuits shall be in separate conduits including small fan circuit unless combination fan-light fixture.

b. Power conductors derived from uninterruptible power supply systems shall not be installed in raceways with conductors of other systems. Install in separate raceways.

c. Intrinsically Safe (IS) circuits shall be run in dedicated raceway and may not be combined with any other circuits.

B. Power and Control Cable:

1. Conductors in panels and electrical equipment shall be bundled and laced at intervals not greater than 6 inches, spread into trees and connected to their respective terminals. Lacing shall be made up with plastic cable ties. Cable ties shall be tensioned and cut off by using a tool specifically designed for the purpose such as a Panduit GS2B. Other methods of cutting cable ties are unacceptable.
2. Conductors crossing hinges shall be bundled into groups not exceeding 10 to 15 conductors and protected using nylon spiral flexible covers to protect conductors. Provide oversized plastic panel wiring duct within panels and panelboards.
3. Slack shall be provided in junction and pull boxes, handholes and manholes. Slack shall be sufficient to allow cables or conductors to be routed along the walls. Amount of slack shall be equal to largest dimension of the enclosure. Provide dedicated electrical wireways and insulated cable holders mounted on unistrut in manholes and handholes.
4. Splices and terminations are subject to inspection by the Owner prior to and after insulating.
5. Motor terminations at 460-volt motors shall be made by bolt-connecting the lugged connectors.
6. In-line splices and tees, where approved by the Owner, shall be made with tubular compression connectors and insulated as specified for motor terminations. Splices and tees in underground handholes or pull boxes shall be insulated using Scotch-cast epoxy resin or Raychem splicing kits.
7. Terminations at solenoid valves, 120 volt motors, and other devices furnished with pigtail leads shall be made using self-insulating tubular compression connectors within the termination box.
8. Terminations at valve and gate motor actuators shall be made directly into the actuator where possible. Power termination shall be made in the actuator power disconnect. Control and signal cable may be routed to a termination box near the actuator on 20-ampere rated terminal strips with label identification for the control and signal conductors. Single wire control conductors and analog cable (SIC or MIC) then installed in flexible conduit to the actuator control and signal termination compartments.
9. Install and route multi-conductor as shown on the drawings. Submit installation and routing layouts of multi -conductor cables branching out to multiple field destinations to the Engineer for pre-approval. If approved, terminate on terminals in a terminal box located adjacent to the first field device served, or in the common junction boxlocated at the equipment as depicted on the motor feed standard detail Drawings. Make final connection to field devices with single conductors.
10. Terminate VFD cable shields in accordance with the cable manufacturer's requirements and recommendations.

C. Signal Cable:
   1. Routing:
      a. Signal circuits shall be run without splices between instruments, terminal boxes, or panels.
      b. Where instrument cable splicing is required, provide a terminal box rated for the area and environment and mounted approximately 3 feet above grade.
      c. Circuits shall not be made using conductors from different pairs or triads. Triads shall be used wherever 3-wire circuits are required.
   2. Cable shields:
      a. Bond shields to the signal ground bus at the control panel only and isolated from ground at the field instrument/equipment and at other locations.
      b. Terminate shields on terminal blocks at all locations where the signal conductors are terminated on terminal blocks.
      c. Shields are not acceptable as a signal path, except for circuits operating at radio frequencies utilizing coaxial cables. Common ground return conductors for two or more circuits are not acceptable.
   3. Cable for paging, security, voice communication, and telephone systems shall be installed and terminated in compliance with the manufacturers and the Utilities recommendations.

D. Portable Cord:
   1. Portable power cords feeding permanent equipment, such as pendant cords feeding motors for pumps, cranes, hoists, and portable itemowneowns shall have a wire mesh cord grip of flexible stainless steel wire to relieve the tension from the cable termination. Connection of portable cords to permanent wiring shall be accomplished with dedicated boxes and terminal blocks.

E. Conductor and Cable Identification:
   1. Identify each conductor with a unique designation.
      a. Provide identification at each terminal to which the conductor is connected and intermediate boxes, handholes, and manholes.
      b. Provide identification of spare conductors at origin and destination enclosures and intermediate boxes, handholes, and manholes.
   2. Identify conductors to match the identifiers on the Drawings or Schedules.
   3. Where conductors are not labeled on the Drawings or Schedules, identify conductors using the following system: EQUPMENT TAG NUMBER – DESTINATION FIELD TERMINAL NUMBER.
      a. Example: PMP-4300-T1 (480V power conductor to first T lead of pump motor)
      b. Example: LIT-5430-N (120V power conductor to neutral terminal of instrument)
      c. Example: LCP-1100-22 (control conductor to control terminal block 22)
      d. Example: LCP-1100-X3 (third un-terminated spare conductor routed to LCP-1100)

4. Where multiple conductors are in parallel from origin to destination, use the same conductor identifier for both, but add a suffix:
    a. Example: MCC-2500-1-1 (parallel 480V power conductor #1 to the first phase of the MCC main breaker).
    b. Example: MCC-2500-1-2 (parallel 480V power conductor #2 to the first phase of the MCC main breaker).
5. Where factory-wired equipment has terminal numbers different than the conductor numbers shown on the control diagrams:
    a. Show both on the interconnection diagram
    b. Include a copy of the interconnection diagram inside of the equipment cabinet.
6. Conductor and Cable Markers:
    a. Provide identification sleeves for conductors size No. 10 AWG or smaller. Provide locking tab type cable markers for conductors No. 8 AWG and larger. Provide white plastic tabs with conductor identification number permanently embossed. Adhesive strips are not acceptable.
    b. Machine print the letters and numbers that identify each wire on sleeves with permanent black ink with figures 1/8 inch high. Provide white or yellow tubing for sleeves sized to fit the conductor insulation. Shrink the sleeves with hot air after installation to fit the conductor.

3.02 FIELD QUALITY CONTROL

A. Test conductors and cables in accordance with Section 26 08 00.

END OF SECTION

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SECTION 26 05 26

GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

PART 1 GENERAL

1.01 DESCRIPTION

A. This section specifies the system for grounding electrical distribution and utilization equipment, including but not limited to cabinets, motor frames, manholes, instrumentation, metal surfaces of process/mechanical equipment that contain energized electrical components, metal structures and buildings, outdoor metal enclosures, fences and gates.

B. Ground and bond equipment and structures, as required by the National Electrical Code, the Drawings, and this Section.

1.02 REFERENCES:

A. General:

1. This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.
2. Unless otherwise specified, references to documents shall mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid (or on the effective date of the Agreement if there were no Bids). If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued. Where document dates are given in the following listing, references to those documents shall mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, discontinued or replaced.

B. ASTM B3 – Standard Specification for Soft or Annealed Copper Wire

C. IEEE 81 - Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System

D. IEEE 81.2 – Guide for Measurement of Impedance and Safety Characteristics of Large, Extended, or Interconnected Grounding Systems

E. IEEE 837 – Standard for Qualifying Permanent Connections Used in Substation Grounding

F. NECA 331 – Standard for Building and Service Entrance Grounding and Bonding

G. NETA ATS – Standard for Acceptance Testing Specifications for Electrical Power Equipment and Systems

H. NEMA GR1 – Grounding Rod Electrodes and Grounding Rod Electrode Couplings

I. NFPA 70 – National Electrical Code

J. UL 467 – Grounding and Bonding Equipment

1.03 SUBMITTALS:

A. Procedures:
   1. In accordance with Section 01 33 00.

B. Informational Submittals:
   1. Manufacturer's product cutsheets for each type of cable, connector, termination, rod, and test well.

C. Closeout Submittals:
   1. Grounding system test reports.

PART 2 PRODUCTS

2.01 COMPONENTS

A. Grounding and Bonding Cable
   1. Soft-drawn or annealed bare copper, ASTM B3 compliant.
   2. Concentric stranded
   3. Manufacturers:
      a. Cerrowire
      b. Encore Wire
      c. Harger
      d. Service Wire
      e. Southwire
      f. Approved Equal

B. Ground Rods:
   1. Copper covered steel
   2. 3/4-inch diameter and 10-feet long
   3. Threaded type removable caps so that extension rods of same diameter and length may be added where necessary.
   4. UL 467 listed
   5. NEMA GR1 compliant
   6. Manufacturers:
      a. Blackburn
      b. Erico
      c. Harger
      d. Approved Equal

C. Ground Test Wells:
   1. 12” diameter precast concrete test well with cast iron cover labeled “GROUND.”
   2. AASHTO H-20 traffic rated
   3. Manufacturers:
      a. Christy G12
      b. Harger 362TD
      c. KLP P6561
      d. Approved equal

D. Compression Connectors:
   1. Irreversible, cast copper.
   2. UL 467 listed
   3. IEEE 837 compliant for buried or embedded connections
   4. Manufacturers:
      a. Burndy
      b. Blackburn
      c. Ilsco
      d. Approved equal

E. U-Bolt Connectors
   1. Bolted connectors for connections to pipes, fencing, and guard rails.
   2. UL 467 listed
   3. Manufacturers:
      a. Blackburn FG
      b. Burndy G series
      c. Ilsco GPL
      d. Approved equal

F. Equipment Ground Plate
   1. Two-hole copper flush mounted grounding plate embedded in concrete
   2. UL 467 listed
   3. Manufacturers:
      a. Blackburn GP
      b. Burndy YGF
      c. Ilsco CGP
      d. Approved equal

G. Grounding Bars:
   1. Ground electrode grounding bars shall be 1/4-inch thick copper electro-tin plating, Erico Eritech EGBA Series CC Pattern, Burndy Type BBB or equal. Minimum length shall be 12 inches.
   2. Insulators (Stand Off) material shall be halogen-free, fiberglass-reinforced thermal set unsaturated polyester molded compound with indoor rating of 600 volts.

3. Brackets shall be 1/8-inch thick, Type 304 stainless steel.
4. Fasteners shall be 3/8-inch Type 304 stainless steel.

PART 3 EXECUTION

3.01 APPLICATION

A. Connect equipment and structures to the grounding system as indicated on the Drawings and as specified. Where conductor sizes are not shown or specified, provide the following minimum sizes:

Component or System	Minimum Size
Concrete-encased electrode (Ufer)	4/0 AWG
480V MCC	2/0 or 4/0 AWG
Cable tray	2/0 or 4/0 AWG
Lighting & Power panels	2 AWG
Exposed metal cabinets	2 AWG
Buildings and enclosure	2 AWG
Fences and gates	2 AWG
Control Panels	6 AWG
Motors 1 hp to 25 hp	6 AWG
Motors 25 hp to 250 hp	2 AWG

3.02 INSTALLATION

A. General:
   1. Install grounding and bonding systems in accordance with NECA 331 and the grounding component manufacturer's requirements.
   2. Grounding system shall be provided in compliance with the NFPA 70 National Electrical Code (NEC). Grounding conductor shall not be used as a system neutral.
   3. Notify the Owner two hours prior to backfilling, as each part of the grounding system installed below finished grade is complete and ready for inspection. Non-compliance shall affect the payment schedule for this work.

B. Connections:
   1. Embedded and buried ground connections shall be made by compression connectors utilizing diamond or hexagon dies and a hand compression tool for wire sizes 2 AWG and smaller and a hydraulic pump and compression head for wire sizes 2/0 AWG and larger. Alternate method allowed: exothermic welding using a remote igniter device.
   2. Tools and dies shall be approved for this purpose; dimple compressions are not acceptable. Compression connections shall be prepared in accordance with the manufacturer's instructions. Compression-type lugs shall be used in accordance with manufacturer's recommendations. Exposed ground connections to equipment shall be made by bolted clamps unless otherwise specified. No solder material shall be used in any part of the ground circuits.

3. Embedded ground conductors and fittings shall be securely attached to concrete reinforcing steel with tie wires and prevented from displacement during concrete placement.
4. Lightning arresters shall be directly connected to the ground grid system using lightning industry braided copper conductors, sized as specified.

C. Cables and conductors:
1. Grounding conductors which project from a concrete surface shall be located as close as possible to a corner of the equipment pad, protected by rigid conduit bonded to the grounding conductors, or terminated in a flush grounding plate.
2. Grounding conductors extended beyond concrete surfaces for equipment connection shall be extended a sufficient length to reach the final connection point without splicing. Provide grounding fittings, pads, or plates as shown in the electrical details. Minimum grounding conductor extension shall be 3-feet.
3. Exposed grounding conductors shall be supported by noncorrosive metallic hardware at 4-foot intervals or less. Grounding conductors for shown and future equipment shall be terminated using an equipment grounding plate.
4. Metallic sheaths or shields of shielded power cable shall be terminated to a copper ground bus provided with cable connection for connection to the grounding system.

D. Raceways:
1. Service, feeder and branch circuit raceways shall contain a green insulated ground conductor sized per applicable NFPA 70 National Electrical Code (NEC) tables:
   a. T250.66 - Grounding Electrode Conductor for Alternating - Current Systems or
   b. T250.122 - Minimum Size Equipment Grounding Conductors for Grounding Raceways and Equipment.
2. Metallic conduits terminating at concentric knock-outs or reducing washers shall be bonded using insulated grounding bushings. Grounding bushings shall be connected to the grounding system using conductors sized in compliance with NEC.
3. Cable trays shall have 2/0 or 4/0 bare copper ground conductor run on the outside of each tray or tray group of tiered cable tray. Conductor shall be connected to each section or fitting using an approved ground-clamp and supported at 5 foot intervals.

E. Equipment and Enclosure Grounding and Bonding
1. Electrical distribution and utilization equipment enclosure ground bus, motor frames, manholes, metal structures and buildings, outdoor metal enclosures, fences and gates shall be bonded to the grounding system with conductor sizes as specified.
2. Ground conductors entering electrical enclosures shall be bonded to a single ground bus or terminal strip in the enclosure. Direct ground connections to enclosure chassis or back plate are not acceptable. Prior to making ground connections or bonds, the metal surface at the point of connection shall be cleaned.
3. Connect the conductor to the metal enclosure using a UL listed connector, where the enclosure does not contain an internal ground bus
4. All metallic structures and enclosures shall be bonded.

F. Service and Separately Derived System Bonding

1. A neutral bonding jumper shall be installed in only one location for each service or separately derived system. The bonding jumper shall be located at the service source or the first immediate distribution point downstream from the source. The neutral and ground buses shall be kept isolated from each other accept where the bonding jumper is installed.

G. Isolated Grounding

1. An isolated ground system shall be installed where required by an equipment manufacturer. The isolated ground conductor shall have green insulation with a yellow stripe and shall be run in the same raceway as the power and neutral conductors. The isolated ground bus shall be kept isolated from neutral and grounding buses.
2. Where specifically directed by the Owner and required by an equipment manufacturer, the Contractor shall provide an additional isolated ground conductor from the service or separately derived system to an isolated ground bus bar at each associated distribution point.

3.03 FIELD QUALITY CONTROL

A. Test the facility grounding system and the building grounding system to determine the ground resistance. The grounding test shall be IEEE Standard 81 using the NETA Fall-of-Potential procedure. A plot of ground resistance readings for each isolated ground rod, ground mat, or ground bus shall be submitted on 8-1/2 x 11 inch size graph paper. Point-to-point resistance measurements are not acceptable.

B. The current reference rod shall be driven at least 100 feet from the ground rod or grid under test or as recommended by IEEE Standard 81. The measurements shall be made at 10-foot intervals beginning 25 feet from the test electrode and ending 75 feet from it, in direct line between the ground rod or center of grid and the current reference electrode.

C. A grounding system that shows greater than 2 ohm resistance for the flat portion of the plotted data shall be considered inadequately grounded.

D. Provide additional parallel connected ground rods and/or deeper driven rods until the ground resistance measurements meet the 2 ohm requirement. Additional ground rods will be paid for as extra work where the required numbers exceed that specified when authorized and approved by the Owner.

E. Use of salts, water, or compounds to attain the specified ground resistance is not acceptable.

END OF SECTION

SECTION 26 05 33

RACEWAYS AND BOXES FOR ELECTRICAL SYSTEMS

PART 1 GENERAL

1.01 SCOPE

A. This section specifies electrical conduits, fittings, and supports, wireways, pull boxes, manholes, and handholes. Raceways shall be provided for lighting, receptacles, power, control, instrumentation, signaling and grounding systems.

1.02 REFERENCES

A. General:
   1. This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.
   2. Unless otherwise specified, references to documents shall mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid (or on the effective date of the Agreement if there were no Bids). If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued. Where document dates are given in the following listing, references to those documents shall mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, discontinued or replaced.

B. ANSI C80.1 – Rigid Steel Conduit – Zinc Coated

C. ANSI C80.3 – Electrical Metallic Tubing – Zinc Coated

D. ANSI C80.5 – Electrical Rigid Metal Conduit - Aluminum

E. ASTM F512 - Smooth-Wall PolyvinylChloride Conduit and Fittings for Underground Installation

F. FEDSPEC WW-C-581E - Conduit, Metal, Rigid and Intermediate; and Coupling, Elbow, and Nipple, Electrical Conduit; Zinc Coated

G. FEDSPEC W-C-1094A - Conduit and Conduit Fittings, Plastic, Rigid

H. JIC EMP-1 - Electrical Standards for Mass Production Equipment

I. NECA 101 – Standard for Installing Steel Conduits (Rigid, IMC, EMT)

J. NECA 102 – Standard for Installing Aluminum Rigid Metal Conduit

K. NECA 111 – Standard for installing Nonmetallic Raceways (RNC, ENT, LFNC)

L. NECA 605 – Standard for Installing Underground Nonmetallic Utility Duct

M. NEMA ICS 6 - Industrial Control and Systems Enclosures

N. NEMA TC2 - Electrical Plastic Tubing (EPT) and Conduit (EPC 40 and EPC 80)

O. NEMA TC6 - PVC and ABS Plastic Utilities Duct for Underground Installation

P. NEMA TC 14 – Reinforced Thermosetting Resin Conduit (RTRC) and Fittings

Q. NEMA 250 – Enclosures for Electrical Equipment (1000 volts maximum)

R. NFPA 70 – National Electrical Code (NEC)

S. NFPA 79 – Electrical Standards for Industrial Machinery

T. IBC – International Building Code

U. UL 1 – Flexible Metal Conduit

V. UL 6 – Electrical Rigid Metal Conduit - Steel

W. UL 6A – Electrical Rigid Metal Conduit – Aluminum, Red Brass, and Stainless Steel

X. UL 514 - Nonmetallic Outlet Boxes, Flush-Device Boxes and Covers

Y. UL 651 – Schedule 40, 80, Type EB and A Rigid PVC Conduit and Fittings

Z. UL 797 - Electrical Metallic Tubing – Steel

AA. UL 870 - Wireways, Auxiliary Gutters, and Associated Fittings

BB. UL 884 - Underfloor Raceways and Fittings

CC. UL 886 - Outlet Boxes and Fittings for Hazardous (Classified) Locations

DD. UL 1660 – Liquid-tight Flexible Nonmetallic Conduit

EE. UL 2420 – Belowground Reinforced Thermosetting Resin Conduit Fittings

FF. UL 2515 – Aboveground Reinforced Thermosetting Resin Conduit Fittings

1.03 SUBMITTALS

A. Procedures: in accordance with Section 01 33 00.

B. Action Submittals:
   1. Conduit Support Details:
      a. Design and submit installation details showing proposed support methods for wall-, ceiling-, and ground-anchored support systems for raceways.
         1) Installation details shall include bracing where required for the seismic conditions as specified in Section 01 73 24.
         2) Installation details may be typical for a certain size/quantity/weight of raceways and applied to the installation of other groups of raceways up to those amount(s).

C. Informational Submittals:
   1. Manufacturer's cutsheets for each raceway type including associated fittings and boxes.
   2. Certification that the installers have been trained to work on PVC-coated conduit systems.

1.04 SITE CONDITIONS

A. As specified in Section 01 11 80 and 01 73 24.

PART 2 PRODUCTS

2.01 RACEWAY TYPES

A. GRS:
   1. Description: Galvanized rigid steel conduit (GRS)
   2. Compliance: ANSI C80.1 compliant, UL 6 listed
   3. Finish: Hot-dip galvanized after fabrication, inside and outside. Smooth finished surfaces.
   4. Manufacturers: Atkore, Allied Tube and Conduit, Wheatland Tube, approved equal.
   5. Minimum size: 3/4 inch
   6. Elbows:
      a. 3/4" thru 1-1/2" –- Factory fabricated or field bent.
      b. 2" thru 6" –- Factory fabricated only.
   7. Fittings:
      a. Locknuts, Rings, Hubs:
         1) Hot-dip galvanized insulated throat with bonding locknut or ring. The hubs shall utilize a neoprene "O" ring and provide a watertight connection. O-Z Gedney, CHM-XXT, or equal
      b. Unions:
         1) Electro-galvanized ferrous alloy type Appleton UNF or UNY, Crouse-Hinds UNF or UNY, or equal. Threadless fittings are not acceptable.
      c. Conduit Bodies:
         1) Oversized conduit bodies: Ferrous alloy type with screw taps for fastening covers to match the conduit system. Gaskets shall be made of neoprene.

8. Boxes:
    a. Indoor:
        1) Type FD cast ferrous for all device boxes and for junction boxes less than 6 inches square.
    b. Outdoor:
        1) Type FD cast ferrous for all device boxes and for junction boxes less than 6 inches square.
    c. Corrosive:
        1) NEMA 4X stainless steel or nonmetallic, as specified.
    d. Hazardous:
        1) NEMA Class 7 cast ferrous or aluminum.
9. Conduit Bodies (Oversized):
    a. 3/4" thru 4" –- Malleable iron, hot-dip galvanized, unless otherwise noted. Neoprene gaskets for all access plates. Tapered threads for conduit entrances.
    b. 5" and 6" –- Electro-galvanized iron or cast iron box.
10. Manufacturers:
    a. Appleton, Crouse-Hinds, Hubbell, O. Z. Gedney, approved equal.
11. Installation:
    a. Rigid steel conduit shall be made up tight and with conductive thread compound. Joints shall be made with standard couplings or threaded unions. Steel conduit shall be supported away from the structures using hot-dip galvanized malleable iron straps with nesting backs or framing channel.
    b. Conduit entering boxes shall be terminated with a threaded hub with a grounding bushing.
    c. Exposed male threads on rigid steel conduit shall be coated with zinc-rich paint.

B. PGRS:
1. Description: Rigid steel conduit, corrosion-resistant, polyvinyl chloride (PVC) coated.
2. Compliance: ANSI C80.1 and NEMA RN 1 compliant, UL 6 listed
3. Finish:
    a. Hot-dip galvanized rigid steel conduit as specified in for type GRS, with a PVC Coating. The PVC coating shall be gray, minimum 40 mils thick, bonded to the outside and continuous over the entire length of the conduit except at the threads, and be free of blisters, bubbles, or pinholes. Thread protectors shall be used on the exposed threads of the PVC coated conduit.
    b. A 2-mil coat of urethane enamel coating shall be bonded to the inside. Coating shall be free of pinholes. Bond strength shall exceed the tensile strength of the PVC coat.
4. Elbows:
    a. Factory fabricated only.

5. Fittings:
    a. Similarly coated to the same thickness as the conduit and provided with Type 316 stainless steel hardware. Conduit and fittings shall be manufactured by the same company Conduit and fittings shall be coated by the same company. Male threads on elbows and nipples, and female threads on fittings or conduit couplings shall be protected by application of urethane coating.
6. Covers:
    a. PVC coated covers shall have V-groove seal and stainless steel hardware.
7. Hubs:
    a. Hubs for connection of conduit to junction, device, or terminal boxes shall be threaded cast ferrous alloy.
    b. Hubs shall have the same PVC coating as the conduit and insulating grounding bushings. Hubs shall utilize a neoprene "O" ring and shall provide a watertight connection.
8. Boxes:
    a. Nonhazardous:
        1) NEMA Class 4X stainless steel or nonmetallic.
    b. Hazardous:
        1) NEMA Class 7 cast ferrous.
9. Manufacturers: Calbond, Perma-Cote, Plasti-Bond, Ocal, approved equal
10. Installation:
    a. Plastic coated conduit shall be made up tight, threaded, and installed using tools approved by the PVC-coated conduit manufacturer.
    b. Exposed conduit threads shall be covered by a plastic overlap coated and sealed per manufacturer's recommendations.
    c. Pipe wrenches and channel locks shall not be used for tightening plastic coated conduits. Damaged areas shall be patched, using manufacturer's recommended material. The area to be patched shall be built up to the full thickness of the coating. Painted fittings are not acceptable.
    d. PVC coated conduit shall be supported away from the structure using PVC coated conduit wall hangers or PVC coated conduit mounting hardware.
    e. Damaged work shall be replaced
11. Training:
    a. Installers shall be trained and certified in the proper installation techniques provided by the PVC-coated conduit system manufacturer.

C. RAC:
1. Description: Rigid aluminum conduit
2. Materials: 6063 aluminum alloy with temper designation T-1.
3. Compliance: ANSI C80.5 compliant, UL 6A listed
4. Finish: Smooth finished outside and inside surfaces.
5. Manufacturers: Atkore, Allied Tube and Conduit, Wheatland Tube Co, approved equal
6. Minimum size: 3/4 inch

7. Elbows:
    a. 3/4" thru 1-1/2" –- Factory fabricated or field bent.
    b. 2" thru 6" –- Factory fabricated only.
8. Fittings:
    a. Locknuts: Stainless steel.
    b. Bushings:
        1) Non-corrosive cast aluminum alloy, stainless steel, or nonmetallic,
        2) With insulating collar
    c. Grounding Bushings: locking type with a feed-through compression lug for securing the ground cables.
    d. Threadless fittings: not acceptable.
    e. Manufacturers: Thomas & Betts, O.Z. Gedney, Crouse–Hinds, approved equal
9. Deflection/Expansion Fittings:
    a. Allowing for 3/4-inch movement in any direction, including offset or axial.
    b. Hot dip galvanized body, flexible jacket and sleeve, stainless steel clamps.
    c. Integral bonding jumper.
    d. UL 514B listed for direct burial and wet locations.
    e. Manufacturers: Appleton DX, Crouse-Hinds XD, Hubbell DF, OZ/Gedney DX, approved equal
10. Hubs:
    a. Threaded non-corrosive cast aluminum alloy with powdered epoxy finish for connection of conduit to junction, device, or terminal boxes.
    b. Insulating bushings with bonding locknut.
    c. Neoprene "O" ring for a watertight connection.
    d. Manufacturers: O-Z Gedney CHM-XXT, approved equal
11. Unions:
    a. Unions shall be non-ferrous alloy type.
    b. Manufacturers: Appleton UNF or UNY, Crouse-Hinds UNF or UNY, approved equal.
12. Boxes:
    a. Indoor:
        1) Type FD cast aluminum with powdered epoxy finish for device boxes and junction boxes with a dimension less than 6 inches for the longest side.
        2) NEMA Class 12 welded aluminum with threaded hubs with a dimension of 6 inches for the longest side and larger.
        3) Boxes in wet locations: PVC coated.
    b. Outdoor:
        1) Type FD, PVC coated, cast aluminum for device boxes and junction boxes with a dimension of less than 6 inches for the longest side.
        2) NEMA Class 4X welded stainless steel with threaded hubs for a dimension of 6 inches for the longest side and larger:.
    c. Corrosive: NEMA 4X, stainless steel or PVC coated cast aluminum.
    d. Hazardous: NEMA Class 7 cast aluminum.

13. Conduit Bodies:
    a. 3/4" thru 4" –- Oversized conduit bodies: non-ferrous, copper-free aluminum alloy type with powdered epoxy finish and screw taps for fastening covers.
        1) Gaskets shall be made of neoprene.
        2) Tapered threads for conduit entrances.
    b. 5" and 6" –- Cast aluminum box.
14. Manufacturers:
    a. Appleton, Crouse-Hinds, Hubbell, O. Z. Gedney, or equal.
15. Installation:
    a. Joints: made with standard couplings or threaded unions. RAC:
        1) Made up tight with thread compound by Ideal, NoAlox anti-oxidant, Crouse-Hinds STL or equal.
        2) Supported away from the structures and concrete using stainless steel straps with nesting backs.
        3) Terminate with a threaded hub with a grounding bushing where entering boxes.
        4) Exposed male threads on rigid aluminum conduit shall be coated with Teflon-rich product.
        5) Threaded with manufacture approved special dies and bent proper tools.

D. PRAC:
1. Description: Rigid aluminum conduit, corrosion-resistant, polyvinyl chloride (PVC) coated
2. Compliance: ANSI C80.5 compliant, UL 6A listed
3. Finish: Smooth finished outside and inside surfaces. The rigid aluminum conduit shall have a minimum 40-mil thick PVC coating bonded to the outside of the conduit. A 2-mil coat of urethane coating shall be bonded to the inside. Coating shall be free of pinholes. Bond strength shall exceed the tensile strength of the PVC coat. Elbows shall be factory made and coated.
4. Manufacturers: Calbond, Perma-Cote, Plasti-Bond, Ocal, approved equal
5. Minimum size: 3/4 inch
6. Elbows:
    a. Factory fabricated only.
7. Fittings:
    a. Similarly coated to the same thickness as the conduit and provided with type 316 stainless steel hardware. Conduit and fittings shall be manufactured by the same company.
8. Hubs:
    a. Hubs for connection of conduit to junction, device, or terminal boxes shall be threaded and made of cast aluminum alloy.
    b. PVC coating and insulated grounding bushings with a neoprene "O" ring for a watertight connection.

9. Boxes:
    a. Nonhazardous:
        1) NEMA Class 4X stainless steel or PVC coated cast aluminum.
    b. Hazardous:
        1) PVC coated NEMA Class 7 cast alloy.
10. Installation:
    a. PRAC shall be made up tight, threaded, and installed using tools approved by the conduit manufacturer. All conduit threads shall be covered by a plastic overlap which shall be coated and sealed per manufacturer's recommendations.
    b. Pipe wrenches and channel locks shall not be used for tightening plastic coated conduits. Damaged areas shall be patched, using manufacturer's recommended material. The area to be patched shall be built up to the full thickness of the coating.
    c. PRAC shall be supported away from the structure and concrete using PVC coated conduit wall hangers or PVC coated conduit mounting hardware.
    d. Installers of PVC coated conduit shall be certified by the conduit manufacturer that they have received instruction on how to install PVC coated products.

E. EMT:
1. Description: Electrical metallic tubing
2. Compliance: ANSI C80.3 compliant, UL 797 listed
3. Finish: Electro-galvanized steel
4. Minimum size: 3/4 inch
5. Fittings: Compression type.
    a. Fittings inside concrete block (CMU) walls: concrete-tight.
6. Boxes:
    a. Electro-galvanized sheet steel.
    b. NEMA Class 1 stamped or form-bent steel with screw covers.

F. PVC40:
1. Description: Rigid PVC conduit
2. Compliance: NEMA TC2 compliant, UL 651 listed
3. Construction: Schedule 40, high-impact, polyvinylchloride (PVC)
4. Minimum size: 3/4 inch
5. Fittings:
    a. PVC solvent weld type
6. Boxes:
    a. Indoor: NEMA 4, nonmetallic
    b. Outdoor and corrosive: NEMA 4X, nonmetallic
7. Installation:
    a. PVC conduit entering fiberglass boxes or cabinets shall be secured by threaded bushings on the interior of the box and shall be terminated with a threaded male terminal adapter having a neoprene O ring.

b. Joints shall be made with standard PVC couplings.
c. PVC conduit shall have bell ends where terminated at walls and boxes.

G. PVC80:
1. Description: Rigid PVC conduit, heavy wall
2. Compliance: NEMA TC2 compliant, UL 651 listed
3. Construction: Schedule 80, high-impact, polyvinylchloride (PVC)
4. Minimum size: 3/4 inch
5. Fittings:
a. PVC solvent weld type
6. Boxes:
a. Indoor: NEMA 4X nonmetallic
7. Outdoor and corrosive: NEMA 4X nonmetallic
8. Installation:
a. PVC conduit entering FRP boxes or cabinets shall be secured by threaded bushings on the interior of the box and shall be terminated with a threaded male terminal adapter having a neoprene O ring.
b. Joints shall be made with standard PVC couplings.
c. PVC conduit shall have bell ends where terminated at walls and boxes.

H. FMC:
1. Description: Flexible steel conduit
2. Compliance: UL 1 listed
3. Construction: Spirally wound galvanized steel strip with successive convolutions securely interlocked.
4. Minimum size: 1/2 inch
5. Fittings: Compression type
6. Other: Provided with an internal ground wire.

I. LFMC:
1. Description: Liquid-tight flexible steel conduit
2. Compliance: UL 360 listed
3. Construction: Spirally wound galvanized steel strip with successive convolutions securely interlocked and jacketed with liquid-tight plastic cover.
4. Manufacturers: AFC, Anamet, Electri-flex, Southwire, Thomas & Betts, approved equal
5. Minimum Size: 3/4 inch
6. Fittings:
a. Zinc-plated steel body and gland nut, grounding ferrule threaded to engage conduit spiral.
b. O-ring seals around the conduit and box connection and insulated throat.
c. Provide forty-five and ninety degree fittings where applicable.
d. Provide PVC coated flexible conduit and fittings where the conduit system is PVC coated.

7. Installation:
    a. Length shall not exceed 15 times the trade diameter of the conduit and not exceed 36 inches in length. Use conductive thread compound.

J. LFNC:
1. Description: Liquid-tight flexible nonmetallic conduit
2. Compliance: UL 1660 listed
3. Construction: Rigid PVC coil embedded in a flexible PVC outer wall
4. Minimum Size: 3/4 inch
5. Manufacturers: Anamet, Electri-flex, Southwire, approved equal
6. Fittings:
    a. Nylon body, gland nut, locknut
    b. O-ring seals around the conduit and box connection and insulated throat.
    c. Provide forty-five and ninety degree fittings where applicable.
7. Installation:
    a. Length shall not exceed 15 times the trade diameter of the conduit and not exceed 36 inches in length. Use conductive thread compound.

2.02 RACEWAY HANGERS AND SUPPORTS

A. Conduit Supports:
1. Framing channel with end caps and straps shall be provided to support groups of conduit. Individual conduit supports shall be one-hole pipe straps used with clamp backs and nesting backs where required.
2. Conduit supports shall be one-hole clamps or oversized clamps with clamp backs and nesting backs where required.
3. Fiberglass spray sealant shall be applied to all field cuts made to fiberglass framing channel.

B. Ceiling Hangers:
1. Ceiling hangers shall be adjustable. Provide J-Type conduit support for single conduit. Straps or hangers of plumber's perforated tape are not acceptable. Unless otherwise shown, hanger rods shall meet ASTM A193 and be sized as 3/8-inch up to 2-inch conduit and shall be 1/2 inch all-thread rod over 2-inch conduit.
2. Ceiling hangers for fiberglass framing channel shall be 1/2 inch fiberglass reinforced plastic threaded rod hangers with FRP fasteners.

C. Suspended Raceway Supports and Racks:
1. Suspended raceway supports shall consist of concrete inserts, rod hangers, and jamb nuts supporting framing channel or lay-in pipe hangers as required. Framing channel shall be a minimum of 12-gauge.
2. Hanger rods supporting fiberglass framing channel shall be 1/2 inch fiberglass reinforced plastic with FRP or nylon jamb nuts.
3. Hanger rods shall be 1/2-inch diameter all-thread rod and shall meet ASTM A193.

D. Materials:
   1. Provide raceway hangers and supports suitable for the area and environment of installation in accordance with Section 26 05 00.

E. Bracing and Anchorage:
   1. Suspended raceway supports and racks shall be braced for seismic forces as specified in Section 26 05 00.

2.03 BOXES, GUTTERS, AND TERMINAL CABINETS

A. Materials and classifications of equipment and material is specified in Section 26 05 00

B. Pull Boxes And Wiring Gutters:
   1. Indoor boxes and enclosures larger than FD boxes shall be constructed of sheet steel and galvanized after fabrication. Outdoor boxes and enclosures shall be provided with neoprene gaskets on the hinged doors and removable covers. Box and gutter sizes, metal thickness, and grounding shall comply with the National Electrical Code. Bolt-on junction box covers 3 feet square or larger, or heavier than 25 pounds, shall have a rigid handle. Covers larger than 3 x 4 feet shall be split.

C. Terminal Cabinets:
   1. Terminal cabinets shall be provided with adjustable terminal strip mounting, back-panels for equipment mounting, print pockets in the doors, continuous door hinges, and three-point lockable latches.
   2. Classifications, ratings and enclosure material is specified in 01 61 45 and 26 05 00.

2.04 COMPONENTS AND MATERIALS

A. Conduit Thread Lubricant:
   1. Thread lubricant shall be conductive with anti-seize and anti-corrosion properties, compatible with steel and aluminum conduit materials.
   2. Manufacturer: T&B CP8 KOPR-Shield, Robroy Thread Compound, approved equal.

B. Raceway Identification:
   1. Solid 316SS tags with minimum 22 gauge thickness.
   2. Raceway identifier stamped or engraved in 3/16-inch minimum height characters
   3. Attached to the raceway with 316 stainless steel wire.

C. Pulling Line:
   1. Lubricated pull tape with sequential footage markings. Provide in all “future” or “spare” raceways.
   2. Manufacturer: Chase Muletape, approved equal.

D. Expansion/Deflection Fittings:
   1. Rigid metal conduit: Provide O-Z Gedney "Type DX" or Crouse-Hinds "Type XD" bonded,

2. PVC-coated Rigid metal conduit: Provide Cal-Bond "Type XD" or O-Cal "Type XD" bonded, expansion and deflection fitting where conduit across structural joints that crosses structural movement.
3. Rigid PVC conduit: Provide Carlon "Type XD" non-metallic expansion/deflection coupling or approved equal

E. Conduit Through-Wall Seal:
1. Two part seal that provides waterproof barrier by compressing a polymeric seal material around the conduit and into the wall opening.
2. Pressure Plates: hot dip galvanized, PVC-coated or stainless steel
3. Bolts: Stainless steel
4. Manufacturer: Garlock Link-seal, O-Z Gedney FSK, Roxtec RS UG, approved equal

F. Deflection/Expansion Fittings:
1. Allowing for 3/4-inch movement in any direction, including offset or axial.
2. Flexible jacket and sleeve, stainless steel clamps, Integral bonding jumper.
3. Materials:
   a. Rigid metallic conduit systems: Hot dip galvanized body
   b. PVC coated rigid metallic systems: PVC-coated steel body, coating thickness/configuration to match conduits.
   c. PVC conduit: PVC body
4. UL 514B listed for direct burial and wet locations.
5. Manufacturers:
   a. Rigid metallic conduit: Appleton DX, Crouse-Hinds XD, Hubbell DF, OZ/Gedney DX, approved equal
   b. PVC-coated conduit: Match PVC-coated conduit manufacturer, approved equal
   c. PVC conduit: Carlon XD, approved equal

G. Conduit Sealing Fittings:
1. 40-percent fill type
2. UL 1203 listed
3. Materials:
   a. Steel conduit: hot-dip galvanized cast ferrous alloy
   b. PVC-coated steel conduit: PVC-coated steel, inner and outer coating to match conduit
   c. Aluminum conduit: aluminum alloy
4. With integral drain fitting where installed in vertical runs.
5. Manufacturers: Appleton, Crouse-Hinds, PVC-Coated Steel Conduit Manufacturer, Approved Equal

H. Electrical Sealing Compound - Hardening:
1. System consisting of packing fiber and hardening, non-shrinking, pour-in sealing compound that when installed in a sealing fitting, provides a seal around conductors that prevents the spread of gasses, vapors, and flames.

2. UL listed for Class I, Division 1&2, Group C and D applications
3. Manufacturers: Crouse-Hinds, Hubbell-Killark, Approved Equal

I. Electrical Sealant – non-hardening:
1. Permanently non-hardening, hand-shapable, non-corrosive, oil-based compound designed to restrict the passage of moisture and gasses.
2. Manufacturers: Appleton Duxseal, Ideal Duct Seal, Panduit DS1, Approved Equal

J. Conduit Sealing Foam:
1. System consisting of backer material and closed cell foam that provides a seal around conductors to prevents the spread of moisture, gasses, vapors.
2. Designed to bond to PVC, galvanized steel, and RTRC (FRP) conduit, compatible with cable jacket materials.
3. Manufacturers: Dura-line Hydra-Seal, Polywater FST, Approved Equal.

PART 3 EXECUTION

3.01 APPLICATION

A. Exposed raceways, boxes, enclosures, cabinets, wireways, and gutters: provide as specified for the area and environment of installation in Section 26 05 00.

B. Raceways embedded in concrete floors and walls: provide PVC40 conduit

C. Raceways encased in concrete duct banks: provide PVC40 [or RTRC] conduit

D. Direct buried raceways: provide PVC80 conduit

3.02 INSTALLATION

A. General:
1. Install rigid steel conduit in accordance with NECA 101.
2. Install rigid aluminum conduit in accordance with NECA 102.
3. Install aboveground nonmetallic conduit in accordance with NECA 111.
4. Install underground nonmetallic conduit in accordance with NECA 605.
5. Install conduits such that the total bends between accessible pull locations does not exceed 360 degrees.
6. Prior to installing any new penetrations in existing walls or floors, locate and mark all embedded materials in existing walls (reinforcing bars, piping, conduits, etc.) using X-ray detection, penetrating radar detection, or approved alternate means. Install new penetrations at locations that do not conflict with existing embedded materials in the wall.

7. Penetrations and openings in structures (including walls and floors):
    a. New structures: install openings up to 3 feet wide in the longest dimension or groupings of smaller openings up to 3 feet in the longest dimension between outermost openings in any direction in accordance with the Drawings/Details, including the installation of additional reinforcing around openings. For proposed larger openings where block outs are not already identified on the Drawings, submit proposed installation method to the Structural Engineer of Record for review.
    b. Existing structures:
        1) Install openings up to 5" in diameter or blockouts or groups of openings up to 12" in the longest dimension in accordance with the Drawings/Details, including the minimum spacing between openings. For proposed larger openings where block outs are not already identified on the Drawings, submit proposed installation method to the Structural Engineer of Record for review.

B. Indoor and Outdoor Conduit Systems:
    1. Conduit routing:
        a. Route and install conduits in accordance with the following requirements:
            1) Conduits for outlets and lighting: exposed
            2) Conduits for process, mechanical, and HVAC equipment and instruments: exposed
            3) Other conduit inside structures: exposed
        b. Install exposed conduit parallel or perpendicular to structural members and surfaces. Install conduit horizontally and allow minimum headroom of 7 feet.
        c. Route two or more exposed conduits in the same general routing parallel with symmetrical bends.
        d. Space exposed conduit installed on supports not more than 10 feet apart. Space multiple conduits in parallel and use framing channel.
        e. Secure conduit rack supports to concrete walls and ceilings with cast-in-place anchors or framing channel concrete inserts.
        f. Install conduits at least 6 inches from high temperature piping, ducts, and flues with temperatures higher than 90 degree C.
        g. Provide embedded portions of conduits for future equipment where the Drawings indicate future equipment. Match the relative conduit stub up locations for future equipment to the stub up locations for equipment being installed now.
    2. Conduit penetrations:
        a. Roofs and metal walls: Provide conduits with flashed and watertight seals routed through roofs or metal walls.
        b. Concrete and masonry:
            1) Non-fire-rated walls and floors: Grout conduits into openings cut into concrete and masonry structures.
            2) Fire-rated walls and floors: Provide firestopping of all raceway penetrations in rated walls.
    3. Conduit terminations:
        a. Conduits that enter enclosures: terminate with fittings that match the NEMA rating of the enclosure.

b. Spare, future, and empty conduits:
    1) Stubbing up through a raised equipment pad or curb: Install cap.
    2) Stubbing up through the floor: Install spare conduit flush with structural surfaces with coupling and plug as shown on the Drawings or Details.
    3) Caps and plugs shall match the conduit system.
    4) Apply anti-seize compound on cap and plug threads prior to installation.
c. Motor connections:
    1) Prior to rough-in, verify that the motors procured are provided with the correct size and orientation motor termination boxes to accept the raceways and conductors routed to them, or provide a custom-fabricated termination box and submit a material, size, gasket, termination kit, grounding terminal, motor lead connection method, and motor terminal box connection/support system demonstrating that the propose box is compatible with the planned motor and raceway system.

4. Conduit Sealing Fittings:
    a. Provide conduit sealing fittings with hardening sealing compound for hazardous (classified) areas where required by the NEC and as indicated on the Drawings or Details.
    b. Install the seal-off material in the conduit seal-off fittings after inspection.
5. Installation at structural joints:
    a. Provide deflection/expansion fittings where conduit across structural joints that allow for structural movement.
6. Conduit in block walls:
    a. Install multiple runs of conduit that stub-up into a block wall and connect to recessed electrical panels with adequate space for the conduit. Coordinate the electrical work with the structural work and block installers to provide a chase to install the conduit. Install conduit in the cells that do not contain structural reinforcement. Install conduits in the center of the cell to avoid affecting the structural integrity of the wall.
    b. Avoid conduit and electrical boxes installation that blocks the cell from being grouted or that blocks the cell reinforcing bars from being grouted. Avoid conduit in the first cell adjacent to doors, windows, corners and wall intersections and install conduits in the center of the first available cell a minimum of 1'-0" from the edge of these openings.
    c. Where solid grouting of masonry walls is specified, install conduit and electrical boxes so as to provide sufficient space for grout to flow pass the boxes and conduit in order to fully fill the space beneath and behind. Where boxes need to be held in place, secure the boxes from the face of the block wall. Do not place items behind or next to electrical boxes to hold in place.
    d. Coordinate split-face, slump and scored block installation with the masonry contractor to supply smooth face block at the location of receptacles and switches so that the device covers install flush to the wall. Install translucent weather-proof sealing material under device covers on outdoor or wet area locations.

3.03 RACEWAY IDENTIFICATION

A. Provide a permanent raceway identification tag on each new and reused conduit at each end and at each pull box, terminal box, wireway, gutter, manhole or handhole.

B. Raceway Numbers:

1. Tag raceways at all terminations. Raceway numbers will comply with raceway labels assigned on the drawings. Where raceway numbers have not been assigned, assign raceway numbers in accordance with the following system:

Raceway Prefix	Type of Function
H	Power >600V
P	Power <=600V
C	Control or power - 120V or less
S	Signal - data communication or instrumentation
N	Network communication
X	Spare

2. Provide 4-digit number after the prefixes. Add a letter suffix to distinguish the raceways where more than one raceway is routed to a particular piece of equipment. Example: Raceway number = P3109A where:
   a. P = conduit contains power
   b. 3109 = unique 4-digit number
   c. A = letter to distinguish raceways to same equipment

3.04 RACEWAY SCHEDULE

A. Unscheduled Raceway:

1. Size unscheduled raceways (including lighting, receptacle, fire alarm, security, and communication circuits) in accordance with the NEC. Minimum size shall be 3/4 inch for exposed and 1 inch for embedded raceway.
2. Provide the number and size of unscheduled raceways as required for the particular equipment provided, subject to the minimum sizes specified herein.

END OF SECTION

SECTION 26 05 73

POWER SYSTEM STUDIES

PART 1 GENERAL

1.01 DESCRIPTION

A. General:
   1. Provide the power system studies (short circuit study, protective device coordination study, and arc flash hazard analysis) specified in this Section.
   2. Provide studies for all new and existing equipment. Obtain a copy of the existing electrical system model from the Owner. Update the existing electrical system model format to incorporate the new and modified equipment and use this updated model to provide the studies.
   3. Perform all studies using SKM software.

1.02 REFERENCES

A. General:
   1. This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.
   2. Unless otherwise indicated in the Contract Documents, references to documents shall mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid (or on the effective date of the Agreement if there were no Bids). If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued. Where document dates are given in the following listing, references to those documents shall mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, discontinued or replaced.

B. References:
   1. IEEE 1584 – IEEE Guide for Performing Arc-Flash Hazard Calculations
   2. IEEE 3002.3 - Recommended Practice for Conducting Short-Circuit Studies and Analysis of Industrial and Commercial Power Systems
   3. IEEE 3004.7 - Recommended Practice for Conductor Protection in Industrial and Commercial Power Systems
   4. IEEE 3004.8 - Recommended Practice for Motor Protection in Industrial and Commercial Power Systems
   5. IEEE 3004.9 - Recommended Practice for Protection of Transformers Used in Industrial and Commercial Power Systems
   6. NFPA 70E – Standard for Electrical Safety in the Workplace
   7. NFPA 70– National Electrical Code

1.03 ADMINISTRATIVE REQUIREMENTS

A. Sequencing:
   1. Perform and submit a preliminary short circuit report based on the existing system model (if applicable), data obtained from the utility, estimated cable lengths, and preliminary equipment selections, before ordering any equipment, to verify that the short-circuit current ratings for the equipment being ordered are sufficient for the available fault current.
   2. Submit a draft of the complete report to the Owner for for review and comment. Provide written responses to owner comments and incorporate comments into the final report where applicable.

B. Arc Flash Hazard Label Standard:
   1. Where the studies include work at a facility that has existing arc flash hazard labels, obtain a copy of the most recently installed label(s), confirm the desired contents and format of the label with the Owner , recommend revisions if/as required for compliance with current industry standards, and incorporate Owner comments on the label format

1.04 SUBMITTALS

A. Procedures: in accordance with Section 01 33 00 - Submittal Procedures

B. Action Submittals:
   1. The report specified in this Section.

C. Informational Submittals:
   1. Study professional engineer qualifications: demonstrating that the professional engineer in responsible charge of performing the studies has a minimum of 5 years experience performing short-circuit studies, protective device coordination studies, and arc flash hazard analysis.

D. Closeout Submittals:
   1. Electronic copies of the electrical system model used to develop the report in the model's native software format (e.g. SKM, ETAP, EasyPower), including all custom libraries or support files used to create the report.

1.05 QUALITY ASSURANCE

A. The studies shall be signed by the professional electrical engineer in responsible charge of the studies and registered to practice engineering in the state or commonwealth in which the project is located.

PART 2 PRODUCTS

2.01 REPORT

A. Provide a certified report summarizing the short circuit study, protective device coordination study, and arc flash hazard analysis and include conclusions or recommendations which may affect the integrity of the electric power distribution system. As a minimum, the report shall include the following:
   1. The equipment manufacturer's information used to prepare the study.
   2. Electric utility system information applicable to the project, including dated copies of correspondence from the utility providing the required information.
   3. Short circuit calculations listing short circuit levels at each bus. Provide a sketch of the bus and use both the project term and the bus-code-name to identify the bus, branches, sources, loads. Base the system on the Project One-Line diagram.
      a. Include electric utility equipment that affect the installed equipment’s short circuit ratings and, protective device ratings.
   4. Coordination study time-current characteristic curves including the instrument transformer ratios, model numbers of the protective relays, and the relay settings associated with each breaker.
      a. Include electric utility equipment that affect the installed equipment’s protective device settings.
   5. Comparison of short circuit duties of each bus to the interrupting capacity of the equipment protecting each bus.
   6. Data used as input to the report that includes cable impedances, source impedances, equipment ratings for the equipment being purchased for the project, etc.
   7. Arc flash hazard calculations listing incident energy levels at each bus in accordance with the methods outlined in IEEE Standard 1584 and stated hereinafter.
   8. Arc flash warning labels displaying information in accordance with NFPA 70E requirements including nominal system voltage, arc flash boundary, and at least one of the following: available incident energy and corresponding working distance or the required arc flash personnel protective equipment (PPE) category (but not both), the minimum arc rating of clothing, site specific level of PPE.
   9. Assumptions made during the study.

PART 3 EXECUTION

3.01 GENERAL

A. Provide a short circuit and coordination study on the electrical power distribution system as specified. The studies shall be performed in accordance with IEEE Standards 141 and 242 and shall utilize the ANSI method of short circuit analysis in accordance with ANSI C37.010.

B. The studies shall be performed using actual equipment data for both existing and new equipment.

C. For existing equipment, provide one separate two-person-day trips of onsite investigation ot identify loads and collect power distribution equipment data.

3.02 SHORT CIRCUIT STUDY

A. The Contractor shall be responsible to obtain and verify all data needed to perform the study. As a minimum, the short circuit study shall include the following:
   1. One-Line Diagram
      a. Location and function of each protective device in the system, such as relays, direct-acting trips, fuses, etc.
      b. Type designation, current rating, range or adjustment, manufacturer's style and catalog number for all protective devices.
      c. Power, voltage ratings, impedance, primary and secondary connections of all transformers.
      d. Type, manufacturer, and ratio of all instrument transformers energizing each relay.
      e. Nameplate ratings of all motors and generators with their subtransient reactances. Transient reactances of synchronous motors and generators and synchronous reactances of all generators.
      f. Sources of short circuit currents such as utility ties, generators, synchronous motors, and induction motors.
      g. circuit elements such as transformers, cables, breakers, fuses, reactors, etc.
      h. Emergency as well as normal switching conditions, as applicable.
      i. The time-current setting of existing adjustable relays and direct-acting trips, as applicable.

B. Calculations
   1. Determine the paths and situations where short circuit currents are the greatest.
   2. Study shall address bolted faults and calculate the 3-phase and line-to-ground short circuits of each case.
   3. Calculate the maximum and minimum fault currents.

3.03 PROTECTIVE DEVICE COORDINATION STUDY

A. As a minimum, the coordination study for the power distribution system shall include the following on 5-cycle, log-log graph paper:
   1. Time-current characteristic curve for each protective relay or fuse showing graphically that the settings will provide protection and selectivity within industry standards. Each curve shall be identified, and the complete protective relay settings shall be specified.
   2. Time-current characteristic curves for each device shall be positioned to provide for maximum selectivity to minimize system disturbances during fault clearing. Where selectivity cannot be achieved, notify the Owner of the reason(s) and potential consequences.
      a. Where overcurrent protective devices are provided with energy reducing maintenance switching, provide alternate curves and settings for the overcurrent protective devices when the switch is in energy reducing mode (aka "maintenance mode.")
   3. Time-current characteristic curves and points for cable and equipment damage.
   4. Circuit interrupting device operating and interrupting times.

5. Indicate maximum fault values on the graph.
6. Sketch of bus and breaker arrangement.

3.04 ARC FLASH HAZARD ANALYSIS

A. The Contractor shall be responsible to obtain and verify all data needed to perform the study. The arc flash analysis study shall include the following IEEE Standard 1584 ten step analysis process:
   1. Collect system and installation data.
   2. Determine modes of operation.
   3. Determine bolted fault currents.
   4. Determine typical gap and enclosure size based upon system voltages and classes of equipment.
   5. Determine the equipment electrode configuration.
   6. Determine the working distances.
   7. Calculate arcing current.
   8. Determine the arc duration.
   9. Calculate incident energy.
   10. Calculate the arc flash boundary for all equipment.

3.05 PROTECTIVE DEVICE SETTINGS IMPLEMENTATION

A. The Contractor, via the Testing Firm identified in Section 26 08 00 - Commissioning of Electrical Systems, shall implement the protective device coordination study settings on new and existing equipment per the accepted Protective Device Coordination Study. Report specified herein and submit a final amended report of the Record As-Built electrical equipment protective device settings subsequent to start-up and testing.

3.06 HAZARD LABELS

A. Arc Flash Hazard:
   1. Provide arc flash hazard labels on all equipment included in the arc flash hazard analysis, in accordance with NEC Article 110.16 Arc-Flash Hazard Warning and NFPA 70E requirements.
   2. Include the date the hazard calculation was performed and the name of the entity that performed the calculation on the label.

B. Available Fault Current Marking:
   1. Mark the available fault current as calculated in the short circuit study on all of the following at minimum:
      a. Service equipment (per NEC 110.24)
      b. Switchgear, switchboards, and panelboards (per NEC 408.6)
      c. Motor control centers (per NEC 430.99)
      d. Control panels (per NEC 409.22)

2. Include the date the fault current calculation was performed and the name of the entity that performed the calculation on the label.
3. Provide available fault current marking as part of arc flash hazard label

END OF SECTION

SECTION 26 08 00

COMMISSIONING OF ELECTRICAL SYSTEMS

PART 1 GENERAL

1.01 DESCRIPTION

A. Scope:
   1. Perform acceptance testing for all electrical materials and equipment shown in the Contract Documents and as specified in this Section.
      a. Testing of low voltage electrical conductors/cables and low voltage motors may be performed by qualified personnel of the Contractor.
      b. For testing of all other systems and equipment, retain an independent InterNational Electrical Testing Association (NETA) accredited testing firm (Testing Firm) to perform acceptance testing specified in this Section.
         1) Provide the labor, tools, material, and services, including quality power sources required by the Testing Firm to provide specified tests and retesting.
   2. Tests shall be witnessed by the Owner's Representative. Provide the Construction Manager 30-day advanced notice for Testing Firm tests. Insulation tests by the Contractor typically will not be witnessed. Critical equipment witness testing may be requested by the Construction Manager.
   3. The manufacturer of the electrical equipment supplied for the project shall complete their on-site factory inspection, testing, and setup prior to the Testing Firm's cceptance testing and subsequent protective device setting verification work. The power monitors shall be set up by the factory representatives and power monitor readings and settings verified by the Testing Firm.

1.02 REFERENCES

A. General:
   1. This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.
   2. Unless otherwise specified, references to documents shall mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid (or on the effective date of the Agreement if there were no Bids). If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued. Where document dates are given in the following listing, references to those documents shall mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, discontinued or replaced.

B. ANSI/NETA ATS – International Electrical Testing Association (NETA) – Standard for Acceptance Testing Specifications for Electrical Power Equipment and Systems

1.03 QUALITY ASSURANCE

A. Testing Firm:
   1. The Testing Firm and their proposed project team shall possess the following minimum qualifications:
      a. Testing Firm shall be an independent testing organization providing unbiased testing authority, professionally independent of the manufacturers, suppliers, and installers of equipment or systems to be evaluated.
      b. Testing Firm shall be regularly engaged in the testing of electrical equipment, devices, installations, and systems.
      c. Testing Firm shall be a “NETA Accredited Company” of the InterNational Electrical Testing Association (NETA providing testing in accordance with ANSI/NETA ATS published specifications or the pre-approved firms that use the NETA methods and published testing specifications.
      d. Testing Firm's lead technical person shall be currently certified by NETA or the National Institute for Certification in Engineering Technologies (NICET) in lectrical power distribution systems testing. Submit proof of technical training and certification for performing testing work.
      e. Testing Firm's technicians shall be regularly employed, qualified testing staff.
      f. The following are pre-qualified Testing Firms:
         1) RESA Power
         2) Vertiv (formerly Emerson Electrical Reliability Services)

B. Testing Firm Qualifications:
   1. For any Testing Firm not pre-qualified, the Contractor shall receive Construction Manager approval of the proposed Testing Firm, their proposed project team, and their test procedures prior to the Pre-Test Submittals.
      a. Project Team:
         1) Identify lead technical person and testing staff and provide documentation of training and experience demonstrating compliance with the qualifications specified.
      b. Testing Firm:
         1) Provide reference names and current phone numbers of the Owner, Contractor, Engineer, or Construction Manager that has knowledge of the Firm’s work:
            a) Provide references for five recent projects that were completed within the last four years. Provide a description of the scope of the referenced project.
      c. For Testing Firm’s experience to be judged acceptable, the Contractor shall demonstrate that the proposed Testing Firm's reference projects are of similar scope and size to this project, and in performing these projects the following has been achieved:
         1) Testing Firm's work did not delay the projects or adversely impact the progress of the Contractor's work or the Owner's project.
         2) Specified requirements were achieved.
         3) Work was performed in accordance with ANSI/NETA ATS, MTS, or other Engineer accepted testing criteria.

4) Submittals approved with two or fewer re-submittals after the initial submittal.
5) No warranty claims related to the Testing Firm's work.

1.04 SUBMITTALS

A. Procedures: in accordance with Section 01 33 00.

B. Informational Submittals:
1. Testing Firm Qualifications:
a. For any Testing Firm not pre-qualified per this Section, submit evidence of compliance with the qualifications required by this Section.
b. Documentation of Test Firm NETA Accreditation.

C. Action Submittals:
1. Pre-Test Submittals:
a. Description or samples of specified test procedures.
1) Sample test report forms for the specified tests, demonstrating that the forms document the testing requirements of NETA ATS. Where equipment tested has adjustable settings, test reports must show as tested and as left settings.
2) Preliminary Schedule listing equipment to be tested.
3) Notification form for the work scheduled.
4) Pre-Functional test procedures and testing schedule.
5) Functional test procedures and testing schedule.
2. Post-Test Submittals:
a. Test reports for all test reports performed under this Section.
1) Provide interpretation of test results, including identification of any failures or deficiencies. Minimum acceptable test values shall be as specified in ANSI/NETA ATS. Where acceptance test values are not specified, the equipment manufacturer’s recommended test values shall be used. Where acceptance test values are not specified and the equipment manufacturers recommended test values are not available, request acceptance test values from the Construction Manager.

D. Closeout Submittals:
1. Final copies of all test reports performed under this Section, incorporating all submittal review comments, combined into a single volume that includes all testing performed in different phases over the course of the project.
a. Test report shall be assembled as described in ANSI/NETA ATS. Test results shall be organized by electrical distribution system equipment, project utilization equipment, and electrical conductors with individual tab dividers with labels to identify each group of items and cross-referenced to the Contract Documents. The equipment description, equipment number, and equipment tag number shall be used as shown on the drawings or listed in specifications.
b. Final Test Reports that are illogically assembled, labeled, and organized shall be returned for rework at no cost to the Owner and resubmitted in an acceptable format.

c. Deficiencies and non-compliant test results found during acceptance testing shall be identified in the test report and cover letter. The Testing Firm shall certify in the final test report that all deficiencies and non-compliant test results listed have been "corrected" and shall inclue a description of the resolution for each problem listed.

PART 2 PRODUCTS

2.01 TESTING EQUIPMENT AND INSTRUMENTS

A. The test equipment, instruments and devices used for testing shall be calibrated to test equipment standards with references traceable to the National Institute of Standards and Technology.

B. The test equipment, instruments and devices shall have current calibration stickers indicating date of calibration, deviation from standard, name of calibration laboratory and technician, and date of next recalibration.

PART 3 EXECUTION

3.01 GENERAL

A. The Contractor shall submit a schedule for the Testing Firm work and notify the Construction Manager 30 days prior to commencement of any witnessed testing.

B. The required tests, including correction of defects where found, and subsequent retesting, shall be completed prior to energizing electrical distribution system, utilization systems, and conductors and completed prior to functional testing. The installation of the protective device, breaker, and relay settings shall be completed and verified.

3.02 TESTING

A. Insulation Resistance Measurements:
   1. Insulation resistance measurements shall be made on conductors and electrical equipment that will carry current. Minimum acceptable values of insulation resistance shall be in accordance with the applicable NETA-ATS, ICEA, NEMA, or ANSI standards for the equipment or material being tested. The ambient temperature at which insulation resistance is measured shall be recorded on the test form.

B. Conductor and Cable Tests:
   1. The phase-to-ground insulation resistance shall be measured for circuits 120 volts and above except lighting circuits. Measurements may be made with motors and other load equipment connected. Insulation with resistance of less than 100 megohms is not acceptable.

C. Motor Tests:
   1. Complete the Installed Motor Test Form, Form 26 05 00-B, contained in Section 01 99 90 (or testing firm equivalent) for each motor after installation. All motors shall have their insulation resistance measured before they are connected.
   2. Motors 50 HP and larger shall have their insulation resistance measured at the time of delivery and when they are connected. Insulation resistance values less than 50 megohms are not acceptable.
   3. Verify that motors are connected to rotate in the correct direction with the load disconnected. Verification may be accomplished by momentarily energizing the motor, provided the Contractor confirms that neither the motor nor the driven equipment will be damaged by reverse operation.
   4. Motor running current shall be measured on each phase with the motor operating under load. Current imbalance shall be less than 5-percent difference between phases.

D. Signal and Network Cable Tests:
   1. Signal Cables: Test signal conductors and shield drain for insulation resistance with the other conductors in the cable grounded. Each shield drain conductor shall be tested for continuity. Insulation resistance measurements shall be recorded on Form 40 61 13-A contained in Section 01 99 90 or Testing Firm's equivalent form, and submitted.
      a. Instruments used for continuity measurements shall have a resolution of 0.1 ohms and an accuracy of better than 0.1 percent of reading plus 0.3 ohms. A 500-volt or 1000-volt meg-ohmmeter shall be used for insulation resistance measurements as appropriate.
   2. Network Cables (CAT5/5E/6/6A): Test network cables in accordance with TIA-568-C.2.

E. Equipment Tests:
   1. Perform tests as as specified in ANSI/NETA ATS for all new and modified electrical equipment. Acceptance testing work shall not be limited to equipment shown on the Drawings. Rever to Division 26 for the electrical equipment specified.
      a. Refer to the electrical drawings for location and identification of the electrical distribution system equipment, utilization equipment, and electrical conductors, includes but is not limited to:
         1) Cables Low-Voltage 600 Volt Maximum.
         2) Protective Relays.
         3) Grounding Systems include installed grounding systems and existing grounding systems that are being utilized.
         4) Motors.
         5) Motor Starters Low-Voltage.
         6) Adjustable Speed Drive Systems and harmonic testing per Section 26 29 23-3.02.

F. Pre-Functional Checkout:
   1. Prior to energizing equipment, the Contractor shall perform a pre-functional checkout of the power and the control circuit. Protective devices shall be installed and available for service and calibrated or adjusted with specified setpoints installed. Contractor selected initial setpoints shall be installed and recorded, when specified setpoints are not required from the manufacturer or the Engineer.
   2. Contractor shall submit a description of proposed test and checkout procedures conforming to the following requirements, including a schedule for conducting these procedures, not less than 30 days prior to the performance of pre-functional testing.
   3. Pre-functional checkout shall consist of energizing each control circuit and operating each control device, protective device, monitoring or alarm device, and each interlock and verify the specified action or response occurs. Coordinate testing with the requirements specified in Section 01 91 00.

G. Functional Testing:
   1. Contractor shall submit a description of proposed functional test and checkout procedures conforming to the following requirements, including a schedule for conducting these procedures, not less than 30 days prior to the performance of functional testing.
   2. Prior to functional testing, all protective devices shall be adjusted and made operative. Prior to energization of associated equipment, perform a functional checkout of all electrical and instrumentation control circuits as specified in the following and in Division 40. Checkout shall consist of energizing each control circuit and operating each control, alarm, safety device, and each interlock, in turn, to verify that the specified action occurs.
   3. Record and submit data sheets as specified. Coordinate testing with the requirements specified in Section 01 91 00.

3.03 FIELD QUALITY CONTROL

A. Preliminary Test Reports:
   1. A copy of the preliminary test results shall be provided to the Construction Manager at the end of each day of testing.

B. Test report forms shall include the following information:
   1. Electrical equipment description.
   2. Electrical equipment identification number.
   3. Electrical equipment nameplate data.
   4. Electrical equipment settings.
   5. Time and date of test.
   6. Ambient conditions at time of test.
   7. Inspection checklist and results.
   8. Test results.
   9. Test equipment used with manufacture, model number, and calibration date.
   10. Remarks about test procedures, results, and suggestions.

11. Name and signature of testing personnel.
12. Name and signature of test witness.

END OF SECTION

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SECTION 26 09 16

ELECTRICAL CONTROLS AND RELAYS

PART 1 GENERAL

1.01 DESCRIPTION

A. For all control panels and control stations, including vendor-furnished, manufacturer-furnished, and integrator-furnished equipment: provide enclosures, control devices, relays, overcurrent protection, terminal blocks, wiring, wire identification and color coding, and separation between power, controls, and instruments, as specified herein and in Section 40 67 00.

B. Request clarification where conflicts occur with this section and other sections in Divisions 23, 26, 40, 43, and 46.

1.02 REFERENCES

A. General:

1. This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.
2. Unless otherwise specified, references to documents shall mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid (or on the effective date of the Agreement if there were no Bids). If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued. Where document dates are given in the following listing, references to those documents shall mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, discontinued or replaced.

B. NEMA 250 – Enclosures for Electrical Equipment (1,000 Volts Maximum)

C. NEMA ICS 1 – Industrial Control Systems – General Requirements

D. NEMA ICS 2 – Industrial Control and System: Controllers, Contactors, and Overload Relays Rated 600V

E. UL 50 – Enclosures for Electrical Equipment, Non-Environmental Considerations

F. UL 50E - Enclosures for Electrical Equipment, Environmental Considerations

G. UL 508 – Industrial Control Equipment

1.03 SUBMITTALS

A. Procedures: in accordance with Section 01 33 00.

B. Action Submittals:
   1. Ratings information:
      a. Voltage
      b. Continuous current rating (full load amperes)
      c. Short-circuit current rating (SCCR)
   2. General arrangement drawings:
      a. Plan and elevation drawings showing dimensions, weight, shipping split data, top and bottom conduit entry windows, and anchorage points.
      b. Interior elevation drawing showing components and cable pathways
   3. Schematics (Elementary Diagrams):
      a. Showing all internal and external connections to the control panel
      b. In accordance with NFPA 79.
      c. Matching the switch, pushbutton, indicating light, relay, and contact identifiers from the Contract Drawings where applicable.
   4. Communication Diagram:
      a. Showing network and/or serial connections between motor controllers, circuit breakers, power meters, surge protective devices, network switches, protocol gateways, and other accessories.
   5. Bill of Materials

C. Informational Submittals:
   1. Manufacturer's cutsheets for each component, including control devices, relays, overcurrent protective devices, and enclosures.

D. Closeout Submittals:
   1. Operations and maintenance manual in accordance with Section 01 78 23.

PART 2 PRODUCTS

2.01 CONTROL DEVICES

A. Pushbuttons - Momentary:
   1. Standards: UL 508 listed
   2. Style: flush head
   3. Size: 30.5mm mounting hole
   4. Enclosure rating:
      a. Electrical rooms: NEMA/UL Type 4 water-tight, oil-tight
      b. Other unclassified locations: NEMA/UL Type 4X water-tight, oil-tight, corrosion-resistant

c. Class I, Division 2 locations:
    1) NEMA/UL Type 4X with Class I, Division 2 listed contact blocks or;
    2) NEMA/UL Type 7 if enclosure contains other components with arcing parts
d. Class I, Division 1 locations: NEMA/UL Type 7

5. Color:
    a. Start: green
    b. Stop: red
    c. All other functions: black
6. Legend plates: install around each pushbutton, with text above the button identifying its function as indicated on the Drawings.
7. Temperature operating range: –10 degree C. to +55 degree C.
8. Dielectric strength: 2,200V for 1 minute
9. Contact rating:
    a. NEMA A600 (10A continuous @ 600VAC)
    b. NEMA Q600 (2.5A continuous @ 600VDC)
    c. Installations in Class I, Division 2 locations: contact blocks UL listed for use in Class I, Division 2, Group B, C, and D hazardous locations.
10. Manufacturer:
    a. Allen-Bradley 800T/800H series
    b. Eaton HT800 series
    c. Schneider Electric 9001K/9001SK series
    d. Approved equal

B. Pushbuttons – Emergency Stop:
1. Standards: UL 508 listed
2. Style: Mushroom head, >=40mm diameter, maintained contact, push-pull operation
3. Size: 30.5mm mounting hole
4. Enclosure rating:
    a. Electrical rooms: NEMA/UL Type 4 water-tight, oil-tight
    b. Other unclassified locations: NEMA/UL Type 4X water-tight, oil-tight, corrosion-resistant
    c. Class I, Division 2 locations:
        1) NEMA/UL Type 4X with Class I, Division 2 rated contacts or;
        2) NEMA/UL Type 7 if enclosure contains other components with arcing parts
    d. Class I, Division 1 locations: NEMA/UL Type 7 explosion-proof
5. Color: red
6. Legend plates: install around each pushbutton, with text above the button identifying its function as indicated on the Drawings.
7. Temperature operating range: –10 degree C. to +55 degree C.
8. Dielectric strength: 2,200V for 1 minute

9. Contact rating:
    a. NEMA A600 (10A continuous @ 600VAC)
    b. NEMA Q600 (2.5A continuous @ 600VDC)
    c. Installations in Class I, Division 2 locations: contact blocks UL listed for use in Class I, Division 2, Group B, C, and D hazardous locations.
10. Manufacturer:
    a. Allen-Bradley 800H-FX6 series
    b. Eaton HT8DBR series
    c. Schneider Electric 9001SKR9RH series
    d. Approved equal

C. Selector Switches:
1. Standards: UL 508 listed
2. Style: rotary knob
3. Enclosure rating:
    a. Electrical rooms: NEMA/UL Type 4 water-tight, oil-tight
    b. Other unclassified locations: NEMA/UL Type 4X water-tight, oil-tight, corrosion-resistant
    c. Class I, Division 2 locations:
        1) NEMA/UL Type 4X with Class I, Division 2 rated contacts or;
        2) NEMA/UL Type 7 if enclosure contains other components with arcing parts
    d. Class I, Division 1 locations: NEMA/UL Type 7 explosion-proof
4. Size: 30.5mm mounting hole
5. Color: black with white stripe
6. Legend plates: install around each pushbutton, with text above the button identifying its function as indicated on the Drawings.
7. Temperature operating range: –10 degree C. to +55 degree C.
8. Dielectric strength: 2,200V for 1 minute
9. Contact rating:
    a. NEMA A600 (10A continuous @ 600VAC)
    b. NEMA Q600 (2.5A continuous @ 600VDC)
    c. Installations in Class I, Division 2 locations: contact blocks UL listed for use in Class I, Division 2, Group B, C, and D hazardous locations.
10. Manufacturer:
    a. Allen-Bradley 800T/800H series
    b. Eaton HT800 series
    c. Schneider Electric 9001K/9001SK series
    d. Approved equal

D. Indicating Lights:
1. Standards: UL 508 listed
2. Style: LED lamp, push-to-test
3. Size: 30.5mm mounting hole

4. Enclosure rating:
    a. Electrical rooms: NEMA/UL Type 4 water-tight, oil-tight
    b. Other unclassified locations: NEMA/UL Type 4X water-tight, oil-tight, corrosion-resistant
    c. Class I, Division 2 locations:
        1) NEMA/UL Type 4X with Class I, Division 2 rated contacts or;
        2) NEMA/UL Type 7 if enclosure contains other components with arcing parts
    d. Class I, Division 1 locations: NEMA/UL Type 7 explosion-proof
5. Indicating Light Lens Colors:
    a. Green:
        1) Functions: running, danger, open
        2) Examples: equipment operating, motor running, valve open, power voltage applied, cycle in automatic
    b. Red:
        1) Functions: off, closed, ready
        2) Examples: end of cycle; unit or head returned; motors stopped; motion stopped; contactors open, valve closed
    c. Amber:
        1) Function: fault
        2) Examples: equipment operating, motor running, valve open, power voltage applied, cycle in automatic
    d. White or Clear:
        1) Function: normal condition
        2) Examples: control power on, status okay, normal pressure of air, water, or lubricant
    e. Blue:
        1) Function: advisory condition
        2) Examples: control mode not in automatic, energy-reducing maintenance switch active
6. Dielectric strength: 2,200V for 1 minute
7. Contact rating:
    a. NEMA A600 (10A continuous @ 600VAC)
    b. NEMA Q600 (2.5A continuous @ 600VDC)
    c. Installations in Class I, Division 2 locations: UL listed for use in Class I, Division 2, Group B, C, and D hazardous locations
8. Manufacturer:
    a. Allen-Bradley 800T/800H series
    b. Eaton HT800 series
    c. Schneider Electric 9001K/9001SK series
    d. Approved Equal

2.02 CONTROL RELAYS

A. Logic Level Control Relays:
   1. Application: control logic implementation, circuit seal in, status indication, discrete signal splitting/repeating, interposing between field switches and controller inputs or controller outputs and field devices.
   2. Standards: UL recognized
   3. Style:
      a. Socket type with clear plastic enclosure and hold-down clip
      b. Indicator light showing energized condition
   4. Contacts:
      a. Ratings:
         1) Continuous Current: 10A resistive @ 120VAC or 28VADC
         2) Motor switching duty : 1/6HP @ 120VAC
      b. Configuration:
         1) Form C double-throw
         2) Contact quantity as indicated on the Drawings or required by the application.
   5. Manufacturer:
      a. Allen-Bradley 700-HA/HB
      b. IDEC Series RH
      c. Potter Brumfield series KUP
      d. Approved equal.

B. Timing Relays:
   1. Application:
      a. Timing functions for control logic implementation
   2. Standards: UL recognized
   3. Style:
      a. Socket type with clear plastic enclosure and hold-down clip
      b. Dial indicator showing progress toward timing setpoint
      c. Microprocessor-based with selectable modes, ranges, and setpoints
   4. Contacts:
      a. Ratings:
         1) Continuous Current: 5A resistive @ 240VAC or 28VADC
         2) Motor switching duty : 1/6HP @ 120VAC
      b. Configuration:
         1) Form C double-throw
         2) Contact quantity as indicated on the Drawings or required by the application.
   5. Timing functions: as indicated on the Drawings or required by the application (time delay on, time delay off, one-shot, etc.).
   6. Time delay range: as indicated on the Drawings or required by the application.

7. Manufacturers:
    a. Allen-Bradley 700-HR series
    b. Omron H3CR series
    c. Schneider Electric RE48A series
    d. Approved equal.

2.03 OVERCURRENT PROTECTION

A. Overcurrent Protection:
    1. Circuit Breakers:
        a. General:
            1) Molded case, UL 489 Listed
            2) Stored energy type mechanism to provide quick-make, quick-break, trip-free operation.
            3) Interrupting rating: equal to or greater than the SCCR of the equipment into which they are installed
        b. Less than 225A Trip:
            1) Thermal magnetic trip
    2. Power Fuses:
        a. Provide Class R fuses and fuse holders where required for proper protection of equipment. Fuse clips shall be Class R rejection type and sized for UL Class R, one-time, time-delay fuses. Fuse assembly shall have a minimum short circuit capacity of 100,000 amps symmetrical.
    3. Control Fuses:
        a. Provide fuses for 120 Vac circuits with a minimum of 12,000-amperes interrupting capacity and blown fuse indicators. Fuses for 24 Vdc circuits shall be fast acting glass tube type rated 1/8 or 1/10 amp for 4-20 mA loops. Fuses for 24 Vdc circuits shall be 1/2 amp for the power supply to individual instruments. Fuse holders shall be tip-out or draw-out type.

B. Current Transducers:
    1. Function: convert an AC current measurement to a 4-20mA output
    2. Standards: UL508 listed
    3. Insulation level: 600V
    4. Measured Current Range: as indicated on the Drawings or required for the application
    5. Output: 4-20mA, loop powered
    6. Accuracy: +/- 2% of full scale
    7. Manufacturers:
        a. ABB TSCA
        b. Precision Digital PDA6420
        c. Red Lion CTL
        d. Approved Equal

2.04 SPECIALTY DEVICES

A. Thermostat (Line Voltage):
   1. Type: mechanical with 40-degree to 90-degree Fahrenheit setpoint range.
   2. Contact rating: rated for driven motor or heating load current
   3. Manufacturers:
      a. Corrosive and wet locations (NEMA 4X rated):
         1) Chromalox WCRT-100
         2) Double L TH415
      b. All other locations:
         1) Johnson Controls T26S
         2) Siemens 134-1084
      c. Approved equal

2.05 ENCLOSURES

A. Enclosures for Control Stations and Control Panels:
   1. Provide NEMA/UL enclosure type as specified for the area and environment of installation in Section 26 05 00.

2.06 ACCESSORIES

A. Terminal Blocks:
   1. Power:
      a. Standards: UL 1953 listed or UL 1059 recognized
      b. Style: IP20 finger safe, mechanical set screw connection
      c. Ratings:
         1) Voltage: 600V
         2) Short-circuit current rating (SCCR): as required for the application, marked on terminal block.
      d. Manufacturers:
         1) Allen-Bradley PMDE/PDE series
         2) Eaton PDBFS series
         3) Mersen FSPDB series
         4) Schneider Electric NSYEB series
         5) TE Connectivity CBS50 series
         6) Weidmueller WPD series
         7) Approved equal
   2. Control:
      a. Standards: UL listed or recognized
      b. Style: mechanical strap screw connection
      c. Ratings:
         1) Voltage: 600V
         2) Current: 20A continuous

d. Manufacturers:
    1) Allen-Bradley 1492-J series
    2) Phoenix Contact UT 2,5 series
    3) Weidmuller W series
    4) Approved equal
3. Identification:
    a. Label with overall identifier/number for each terminal block group
    b. Label with individual identifier/number for each terminal
    c. Machine printed text minimum 1/8" high

B. Nameplates
1. Provide nameplates with project-specific identifier(s) for each control station, control panel, relay, and timer in accordance with Section 26 05 00.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install control stations and control panels 48 inches above the floor, ground, or slab to center of device.

B. Test devices in accordance with Section 26 08 00.

END OF SECTION

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SECTION 26 24 19

MOTOR CONTROL CENTERS

PART 1 GENERAL

1.01 DESCRIPTION

A. This section specifies retrofiting motor control centers (MCCs) operating at 480V, 3-phase, 60Hz nominal.

1.02 REFERENCES

A. General:
   1. This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.
   2. Unless otherwise specified, references to documents shall mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid (or on the effective date of the Agreement if there were no Bids). If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued. Where document dates are given in the following listing, references to those documents shall mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, discontinued or replaced.

B. NECA 402 – Standard for Installing and Maintaining Motor Control Centers

C. NEMA 250 – Enclosures for Electrical Equipment (1,000 Volts Maximum)

D. NEMA ICS 1 – Industrial Control Systems – General Requirements

E. NEMA ICS 2 – Industrial Control and System: Controllers, Contactors, and Overload Relays Rated 600V

F. NEMA ICS 2.3 – Instructions for the Handling, Installation, Operation, and Maintenance of Motor Control Centers Rated Not More Than 600V

G. NEMA ICS 18 – Motor Control Centers

H. NFPA 79 – Electrical Standard for Industrial Machinery

I. UL 50 – Enclosures for Electrical Equipment

J. UL 489 – Molded-Case Circuit Breakers

K. UL 845 – Motor Control Centers

1.03 SUBMITTALS

A. Procedures: in accordance with Section 01 33 00.

B. Action Submittals:

1. Specification compliance verification:
    a. 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.
    b. A check mark shall denote full compliance with a paragraph as a whole. If deviations from the specifications are indicated, and therefore requested by the Contractor, each deviation shall be underlined and denoted by a number in the margin to the right of the identified paragraph, referenced to a detailed written explanation of the reasons for requesting the deviation.
    c. Failure to include a copy of the marked-up specification sections, along with justification(s) for any requested deviations to the specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration.
2. Ratings information:
    a. Voltage
    b. Continuous current rating
3. One-line diagram:
    a. Showing the bus arrangement within the MCC, including taps for each unit with designations that match the unit information schedule.
4. Communication diagram:
    a. Showing network and/or serial connections between motor controllers, power meters, circuit breakers, surge protective devices, network switches, protocol gateways, and other accessories.
5. Bill of Materials

C. Informational Submittals:

1. Manufacturer's product data for motor controllers, circuit breakers, and accessories (pilot devices, surge protective devices, power meters, network equipment etc.).
2. Factory test reports

D. Closeout Submittals:

1. Operations and maintenance manual in accordance with Section 01 78 23.
    a. Include final copies of all manufacturer drawings, incorporating all field changes.
    b. Include final copies of all factory and field test reports, including testing performed under Section 26 08 00.
2. Installation certification Form 43 05 11-A as specified in Section 01 99 90.
3. Instruction certification Form 43 05 11-B as specified in Section 01 99 90.

E. Maintenance Materials Submittals:
   1. Spare Parts: furnish at minimum the following:
      a. Fuses: (1) set of each fuse type and size.
      b. Indicating lights: (2) spare indicating lights with lenses of each color light provided.

1.04 QUALITY ASSURANCE

A. MCC buckets shall be listed and labeled per UL 845.

B. All MCCs provided shall be the product of a single manufacturer.

C. The MCC manufacturer shall be the manufacturer of the motor controllers in the MCC.

1.05 SITE CONDITIONS

A. As specified in Section 01 11 80 and 01 73 24.

PART 2 PRODUCTS

2.01 EQUIPMENT ASSEMBLIES

A. Standards:
   1. Compliant with the standards referenced in this Section.

B. Ratings:
   1. Voltage: as indicated on the Drawings
   2. Continuous current: as indicated on the Drawings
   3. Short circuit current rating (SCCR): As indicated on the Drawings
   4. Grounding configuration: as indicated on the Drawings

C. Wiring Class:
   1. NEMA ICS-18 Class II, Type B-T
   2. Pull-apart terminal blocks for control wiring for all removable units and for power wiring for size 1 and 2 starters.

D. Units:
   1. General:
      a. Provide dedicated units for each circuit breaker, motor controller, surge protective device, power meter, and accessory.
      b. Hinged door that opens to only that device
      c. Through-door disconnect operator with position indication
      d. Door-mounted pilot devices and displays (where applicable)
   2. Mounting:
      a. Manual plug-in:
         1) Provide manual plug-in configuration for the following:
            a) Circuit breakers up to 250A

b) FVNR combination starters up to NEMA size 4 (100HP @ 460V/3PH)
c) RVSSs up to 100HP @ 460V/3PH
d) VFDs up to 50HP @ 460V/3PH
2) With self-aligning, tin-plated stabs that positively connect to the vertical bus.
a) Interlocks that prevent the unit from being connected or disconnected from the bus with the unit disconnect handle in the on position.

2.02 MOTOR CONTROLLERS

A. Combination Motor Starter - Full Voltage Non-Reversing (FVNR) or Reversing (FVR):
1. Standards: UL listed as an assembly consisting of the following:
a. Motor circuit protector (MCP)
1) Molded case, UL489 recognized
2) Continuous current rating: as indicated on the Drawings
3) Instantaneous trip: adjustable from 600% to 1300% of continuous current rating
4) Push-to-test button
b. Contactor(s):
1) NEMA ICS 2 compliant
a) Size 1 Minimum
b) IEC-only rated contactors not permitted
c. Overload Relay:
1) Bi-metallic type:
a) Trip Curve Class
(1) General Purpose Pump and Fan Applications: Class 20
(2) Submersible Pumps (wet-pit and dry-pit): Class 10
b) Overload heaters sized to motor nameplate FLA and service factor
c) Reset button
(1) [With through-door operator allowing reset without opening unit door.]
d. Controls: inputs, outputs, switches, pushbuttons, indicating lights, control relays, connections to external components, and logic as indicated on the Drawings.
e. Communications: Ethernet/IP

B. Variable Frequency Drives (VFDs):
1. Standards: UL 508C or UL 61800-5-1 listed.
2. Ratings:
a. Voltage and continuous output current as required for the driven load.
b. Load profile: constant torque when indicated on the Drawings, variable torque otherwise.
c. SCCR: as required to maintain the overall MCC SCCR indicated on the Drawings
3. Architecture:
a. Input protection:
1) Circuit breaker disconnect
2) Current-limiting input fuses where required by UL listing.

b. Output:
1) Pulse-width modulated (PWM) output via insulated gate bipolar transistors (IGBTs).
c. EMI/RFI filter: IEC 61800-3 Category C2 compliant
d. Circuit boards: conformally coated

4. Controls:
a. Door-mounted human machine interface (HMI)
1) Allowing start, stop, local/remote selection, speed adjustment, and programming of parameters.
2) With digital display allowing indication of all monitored values and displaying alarms with identifying text.
b. Inputs, outputs, switches, pushbuttons, indicating lights, control relays, connections to external components, and logic as indicated on the Drawings.

5. Communications: Ethernet/IP port,Two Ethernet/IP ports

6. Monitoring parameters:
a. Motor output:
1) Voltage
2) Current
3) Power
4) Frequency

7. Operational Capabilities:
a. Motor identification / auto-tune: automatically learn motor parameters by sensing response to drive outputs.
b. Catch a spinning load: from a de-energized output state, energize and control an already spinning motor.
c. Volts/Hz ramp with adjustable starting boost
d. Proportional integral derivative (PID) speed control
e. Adjustable output switching frequency
f. Critical frequency avoidance:
1) Minimum two set points selectable from 0 to maximum frequency with set points adjustable from 0-30 Hertz.

C. Reduced-Voltage Solid State (RVSS) Starters:
1. Standards:
a. UL 508 listed.
b. Ratings:
1) Voltage and continuous output current as required for the driven load.
2) SCCR: as required to maintain the overall MCC SCCR indicated on the Drawings

2. Architecture:
a. Input protection:
1) Circuit breaker disconnect with shunt trip for fault isolation
b. Switching:
1) Microprocessor controlled

2) Silicon controlled rectifiers (SCRs) in opposed pairs for each phase
3) Peak Inverse Voltage (PIV): 1,600V minimum

c. Overload Protection:
1) Electronic: selectable class 10, 20, or 30 trip curve

d. Bypass/shorting contactor:
1) Contactor configured to automatically bypass the starter SCRs once the output of the starter is at full voltage and operate continuously at motor full load amps.

e. Circuit boards: conformally coated

3. Controls:
a. Door-mounted human machine interface (HMI):
1) Allowing start, stop, local/remote selection, and programming of parameters.
2) With digital display allowing indication of all monitored values and displaying alarms with identifying text.
3) Alarm log with memory, recording and displaying the last 10 alarms that have been activated.

b. Inputs, outputs, switches, pushbuttons, indicating lights, control relays, connections to external components, and logic as indicated on the Drawings.

4. Communications: Ethernet/IP port,Two Ethernet/IP ports
5. Monitoring parameters: viewable via the HMI and readable via network connection
a. Voltage (each phase)
b. Current (each phase)
c. Power (3-phase kW)
d. Power usage (3-phase kWh)
e. Power factor
6. Operational Capabilities:
a. Capable of starting the driven load (460V, 3-phase, NEMA Design B motor) at the specified ambient temperature and elevation.
b. Rated to supply up to 400% of the motor FLA for 20 seconds at 40 degrees C ambient temperature.
c. Voltage ramp mode with independently adjustable ramp up and ramp down times.
d. Current limit mode with adjustable maximum current in percent of FLA.
e. Torque-controlled ramp mode with independently adjustable ramp up and ramp down times and adjustable initial torque setting.

2.03 COMPONENTS

A. Circuit Breakers:
1. General:
a. Stored energy type mechanism to provide quick-make, quick-break, trip-free operation.
b. Interrupting rating: equal to or greater than the SCCR of the MCC

2. Less than 225A Trip:
    a. Molded case, UL 489 listed
    b. Thermal magnetic trip

B. Pilot devices:
    1. As specified in Section 26 09 16 – Electrical Controls and Relays

C. Wiring:
    1. Power Cables: UL listed, 90C rated copper wire.
    2. Control Cables: UL 1063 listed machine tool wire (MTW), 90C rated copper wire.
        a. Current transformer circuits: provide ring terminal terminations
    3. Network Cables: CAT5E or CAT6, shielded, 600V rated
    4. Identification: provide heat-shrink or locking tab type wire markers at each terminal to which the wire connects.
        a. The letters and numbers that identify each wire shall be machine printed on sleeves with permanent black ink with figures 1/8 inch high. Sleeves shall be white or yellow tubing and sized to fit the conductor insulation.

D. Instrument Transformers:
    1. Provide current and voltage transformers where indicated on the Drawings.
    2. Instrument transformers shall conform to IEEE C57.13.
    3. Wire current transformers through shorting-type terminal blocks before continuing to any other devices.

E. Control Power Transformers:
    1. Where indicated on the Drawings, provide control power transformers with 120VAC secondary for each motor controller unit:
        a. Primary fusing on both lines, secondary fusing on hot, grounded neutral.
        b. Sized to operate motor controller (including inrush current), all control loads, and all external components shown to be connected on the Drawings (including motor anti-condensation heaters, solenoids, motorized dampers, and instruments)
            1) Obtain loads for external components from the component suppliers.
    2. Where required to power devices inside the MCC that are not powered from individual unit control power transformers (e.g. network equipment, anti-condensation heaters), provide control power transformer(s) connected to the line side of the main circuit breaker(s).
        a. Where multiple sources are present, provide a contator to automatically select one of the available sources and continue providing control power to internal equipment.
        b. Provide 120VAC DIN-rail mounted circuit breakers for distribution of 120VAC power to each component in the MCC not powered from an individual unit control power transformer.

F. Power Supplies:
   1. Where 24VDC power is required for communications equipment, power meters, or other components, provide two 480V/3PH-24VDC or 120VAC/1PH to 24VDC power supplies:
      a. Redundancy module to automatically switch between supplies
      b. Individual 24VDC DIN-rail mounted circuit breakers for distribution of 24VDC power to each component within the MCC.

2.04 Accessories

A. Nameplates:
   1. Provide nameplates with project-specific identifier(s) for each overall MCC assembly and each circuit breaker, motor controller, surge protective device, power meter, and powered accessory, in accordance with Section 26 05 00.

B. Lugs:
   1. Provide compression lugs rated 75 degree C and suitable for copper or aluminum wire for all incoming and outgoing phase, neutral, and ground cables that do not terminate directly into a circuit breaker.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install MCC buckets in accordance with NECA 402 and NEMA ICS 2.3.

3.02 FIELD QUALITY CONTROL

A. Adjust settings of circuit breakers and protective relays to the values identified by the the protective device coordination study performed under Section 26 05 73 prior to testing or energizing the MCC.

B. Test MCC buckets in accordance with Section 26 08 00.

C. Provide the services of a factory-trained manufacturer's representative to configure and assist with commissioning of the equipment, including the following activities:
   1. Verify that shipping splits, bus joints, and interconnecting wiring between vertical sections have been installed correctly.
   2. Verify that physical installation (mounting, clearances, conduit and cable entry/terminations, etc.) and mechanical operation (circuit breaker operation, door swing, etc.) comply with manufacturers's recommendations.
   3. Configure and test all safety devices, including energy reducing maintenance switches and permanent electrical safety devices, where appliable.
   4. Motor Controllers:
      a. General:
         1) Configure each motor controller to match the nameplate characteristics and starting requirements of the driven equipment.

2) Implement and test the motor controller logic, inputs, outputs, network connections, local controls, field controls, and indicating lights on the unit control schematics (elementary diagrams).
3) Set class of adjustable overloads based on the recommendations of the driven equipment manufacturer, using the following defaults where the driven equipment manufacturer has no recommended values:
    a) General purpose pump and fan applications: Class 20
    b) Submersible pumps (wet-pit and dry-pit): Class 10

b. VFDs:
1) Perform a static motor identification / tuning operation with the motor de-coupled from the driven load to automatically detect motor parameters and adjust the VFD accordingly.
2) Set acceleration and deceleration ramp times, minimum and maximum speeds based on the needs of the driven equipment, Process Control Descriptions in Section 40 61 96, and optimizations to minimize stress on the motor and driven equipment. Where equipment needs or process control descriptions do not dictate otherwise, apply the following settings:
    a) Positive-displacement pump, fan, and blower and chopper pump applications:
        (1) Control Method: sensorless vector
        (2) Start: linear ramp, 15 seconds minimum
        (3) Stop: freewheel stop
        (4) Emergency stop: freewheel stop
        (5) Loss of network communication: freewheel stop

END OF SECTION

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SECTION 26 28 16

ENCLOSED SWITCHES AND CIRCUIT BREAKERS

PART 1 GENERAL

1.01 DESCRIPTION

A. This section specifies enclosed switches and circuit breakers.

1.02 REFERENCES

A. General:
   1. This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.
   2. Unless otherwise specified, references to documents shall mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid (or on the effective date of the Agreement if there were no Bids). If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued. Where document dates are given in the following listing, references to those documents shall mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, discontinued or replaced.

B. NEMA FU-1 – Low Voltage Cartridge Fuses

C. NEMA KS-1 – Heavy-Duty Enclosed and Dead-Front Switches (600 Volts Maximum)

D. UL 98 – Enclosed and Dead-Front Switches

E. UL 250 – Enclosures for Electrical Equipment

F. UL 489 – Molded-case Circuit Breakers, Switches, and Enclosures

1.03 SUBMITTALS

A. Procedures: in accordance with Section 01 33 00.

B. Action Submittals:
   1. Data for each enclosed switch or circuit breaker:
      a. Voltage
      b. Ampacity
      c. Short-circuit current rating (SCCR)
      d. Bus material

e. Grounding provisions
f. Fuse type where applicable
g. Circuit breaker type where applicable

2. Dimensional drawings

C. Informational Submittals:
1. Manufacturer's product cutsheets

D. Closeout Submittals:
1. Operations and maintenance manual in accordance with Section 01 78 23.

PART 2 PRODUCTS

2.01 3-POLE ENCLOSED SWITCH ASSEMBLIES: STRAIGHT-BLADE

A. Manufacturers:
1. Allen-Bradley 1494G Series
2. ABB TH Series
3. Eaton DH Series
4. Schneider Electric H Series
5. Approved equal

B. Standards:
1. UL 98 listed
2. NEMA KS-1 compliant

C. Features:
1. Enclosure:
a. Dead-front design with hinged door
b. Environmental Rating:
1) Provide NEMA/UL enclosure type as specified for the area of installation as specified in Section 26 05 00.
c. Finish Color: ANSI 61 gray
2. Switch Mechanism:
a. Ratings:
1) Voltage: 600VAC
2) Amps: As indicated on the Drawings
3) Poles: 3
b. Quick-make, quick-break type
c. Straight-blade switch with vertical up/down handle.
d. Line terminal shields
3. Fuses:
a. Where a disconnect switch is indicated as fused on the Drawings, provide Class R current-limiting fuses, conforming to NEMA FU-1, rated minimum 100kAIC.

4. Interlocks:
    a. Preventing door from being opened when the switch is in the “ON” position. With defeat mechanism on switch exterior.
5. Padlocking Provisions:
    a. Suitable to install padlock with 3/8” shank to lock the switch in the OFF position.
    b. Suitable to install padlock with 3/8” shank to lock the hinged door in the CLOSED position.
6. Equipment Ground Bar:
    a. With terminations for incoming and outoing equipment ground cables.
    b. Bonded to switch enclosure.
7. Neutral Bar:
    a. Where a neutral conductor is routed through the enclosure, provide a neutral bar with terminations for incoming and outoing neutral cables.
    b. Electrically isolated from switch enclosure.

2.02 3-POLE ENCLOSED CIRCUIT BREAKER ASSEMBLIES

A. Manufacturers:
1. ABB
2. Eaton
3. Schneider Electric
4. Siemens
5. Approved equal

B. Features:
1. Enclosure:
    a. Dead-front design with hinged door
    b. Environmental Ratings:
        1) Provide NEMA/UL enclosure type as specified for the area of installation as specified in Section 26 05 00.
    c. Finish Color: ANSI 61 gray
2. Circuit Breakers:
    a. General:
        1) Stored energy type mechanism to provide quick-make, quick-break, trip-free operation.
    b. Less than 225A Trip:
        1) Molded case , UL 489 listed
        2) Thermal magnetic trip
3. Operating mechanism:
    a. The circuit breaker shall be operable via a separate handle mounted on the exterior of the enclosure, mechanically linked to the circuit breaker handle inside the enclosure.

4. Interlocks:
    a. Preventing door from being opened when the breaker is in the “ON” position. With defeat mechanism on enclosure exterior.
5. Padlocking Provisions:
    a. Suitable to install padlock with 3/8” shank to lock the breaker in the OFF position.
    b. Suitable to install padlock with 3/8” shank to lock the hinged door in the CLOSED position.
6. Equipment Ground Bar:
    a. With terminations for incoming and outoing equipment ground cables.
    b. Bonded to switch enclosure.
7. Neutral Bar:
    a. Where a neutral conductor is routed through the enclosure, provide a neutral bar with terminations for incoming and outoing neutral cables.
    b. Isolated from switch enclosure.
8. Short-circuit current rating (SCCR): 65 kAIC

2.03 SPARE PARTS

A. Furnish the following:
    1. One set (3) spare fuses for each type and amp rating provided.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install switch assemblies 60 inches above the floor, ground, or slab to center of operating handle.

B. Provide adhesive tag on inside door of each fused switch indicating NEMA fuse class and size installed.

C. Provide a nameplate on each panelboard with its project-specific identifier(s) in accordance with Section 26 05 00. Nameplates must show the equipment tag number, equipment description, and power source as indicated on the Drawings. Provide nameplates regardless of which trade has provided and/or installed the disconnect switch or whether the disconnect switch was factory installed as part of an equipment package.

3.02 FIELD QUALITY CONTROL

A. Test enclosed switches and circuit breakers in accordance with Section 26 08 00.

END OF SECTION

SECTION 26 29 23

VARIABLE FREQUENCY ENCLOSED MOTOR CONTROLLERS

PART 1 GENERAL

1.01 DESCRIPTION

A. Scope:
   1. This section specifies variable frequency enclosed motor controllers that accept a 480V, 3-phase, 60Hz nominal input and producing a pulse width modulated (PWM) output suitable to operate induction motors through a range of speeds.
   2. The term variable frequency drive (VFD) used in the Specifications or on the Drawings refers to variable frequency motor controllers.

1.02 REFERENCES

A. General:
   1. This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.
   2. Unless otherwise specified, references to documents shall mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid (or on the effective date of the Agreement if there were no Bids). If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued. Where document dates are given in the following listing, references to those documents shall mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, discontinued or replaced.

B. IEEE 519 – Standard for Harmonic Control in Electric Power Systems

C. NEMA 250 – Enclosures for Electrical Equipment (1,000 Volts Maximum)

D. NEMA ICS 1 – Industrial Control Systems – General Requirements

E. NEMA ICS 2 – Industrial Control and System: Controllers, Contactors, and Overload Relays Rated 600V

F. NEMA ICS 6 – Industrial Control and Systems – Enclosures

G. NEMA ICS 7 – Adjustable Speed Drives

H. NEMA ICS 7.1 – Safety Standards for Construction and Guide for Selection, Installation and Operation of Adjustable Speed Drive Systems

I. UL 50 – Enclosures for Electrical Equipment

J. UL 489 – Molded-Case Circuit Breakers

K. UL 508A – Industrial Control Panels

L. UL 61800-5-1 – Adjustable Speed Drive Electrical Power Drive Systems – Safety Requirements – Electrical, Thermal, and Energy

1.03 SUBMITTALS

A. Procedures: in accordance with Section 01 33 00.

B. Action Submittals:
   1. Specification compliance verification:
      a. 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.
      b. A check mark shall denote full compliance with a paragraph as a whole. If deviations from the specifications are indicated, and therefore requested by the Contractor, each deviation shall be underlined and denoted by a number in the margin to the right of the identified paragraph, referenced to a detailed written explanation of the reasons for requesting the deviation.
      c. Failure to include a copy of the marked-up specification sections, along with justification(s) for any requested deviations to the specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration.
   2. Ratings information:
      a. Voltage
      b. Continuous current rating (input and output)
      c. Short-circuit current rating (SCCR)
      d. Variable-torque or constant-torque rating
   3. General arrangement drawings:
      a. Plan and elevation drawings showing dimensions, weight, top and bottom conduit entry windows, and anchorage points.
      b. Interior elevation drawings showing arrangement of components within enclosure and termination points for incoming and outgoing cables.
   4. Schematics (Elementary Diagrams):
      a. Showing all internal and external connections to the VFD.
      b. In accordance with NFPA 79 standards.
      c. Matching the switch, pushbutton, indicating light, relay, and contact identifiers from the Contract Drawings.
   5. Communication Diagram:
      a. Showing network and/or serial connections between components within the VFD enclosure and external connections.
   6. Bill of Materials

C. Informational Submittals:
   1. Component datasheets for variable frequency drives and accessories (circuit breakers, input reactors or harmonic filters, output reactors or dv/dt filters, pilot devices, communication cards, protective relays, etc.)
   2. Certification of compatibility with driven load:
      a. Provide certification that the VFDs being provided are suitable for operation of the driven load.
      b. Include a table showing the proposed VFD continuous output current, driven load motor nameplate FLA, load torque characteristic (variable-torque or constant-torque), cable distance from VFD to motor, and motor protection provided (output line reactor, dv/dt filter, or “none required”).

D. Closeout Submittals:
   1. Operations and maintenance manual in accordance with Section 01 78 23.
   2. Installation certification form 43 05 11-Form A, Section 01 99 90.
   3. Instruction certification form 43 05 11-Form B, Section 01 99 90.

E. Maintenance Materials Submittals:
   1. Spare Parts: provide at minimum the following
      a. Fuses: (1) set of each fuse type and size.
      b. Indicating lights: (2) spare indicating lights with lenses of each color light provided.
      c. Operator interface / keypad: one of each type provided.

1.04 QUALITY ASSURANCE

A. Enclosed VFDs shall be listed and labeled for conformance to UL 61800-5-1 or UL508C and UL 508A by a nationally recognized testing laboratory (NRTL).

B. All VFDs provided shall be the product of a single manufacturer.

C. The VFD manufacturer shall have a minimum of 20 years of experience manufacturing 480V enclosed VFDs that have been installed and operated in the United States.

D. Factory Testing:
   1. Energize the VFD and perform burn-in testing with an induction motor connected.
   2. Perform functional testing of VFD to confirm it operates in accordance with the unit control schematic (elementary diagram).
   3. Submit certified test reports.

1.05 SITE CONDITIONS

A. As specified in Section 01 11 80.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. The Owner believes the following candidate manufacturers are capable of producing equipment and/or products that will satisfy the requirements of this Section. This statement, however, shall not be construed as an endorsement of a particular manufacturer's products, nor shall it be construed that named manufacturers' standard equipment or products will comply with the requirements of this Section. Candidate manufacturers include:
   1. Allen-Bradley
   2. Approved equal

2.02 PERFORMANCE REQUIREMENTS

A. Supply Power:
   1. Operate continuously with supply power of 480V +/- 10%, 60Hz +/-3 Hz.

B. Load:
   1. Capable of operating the driven motor continuously at its rated nameplate current (FLA).
   2. Capable off starting and stopping the driven motor and operating it continuously from 6-60Hz.
   3. Rated for operation of constant torque loads when indicated on the Drawings or required by the driven load.
   4. Overloading Capability:
      a. Variable-torque (VT) loads / normal duty: Deliver 110 percent of nameplate load current for up to 60 seconds.
      b. Constant-torque (CT) loads / heavy duty: Deliver 150 percent of nameplate load current for up to 60 seconds.

C. Efficiency:
   1. Not less than 97 percent at 60 Hertz output driving the specified maximum load at rated torque and speed at 40 degrees C ambient
      a. Based on measured VFD input power (kW) versus output power delivered to motor (kW).
      b. Excluding the effects of input reactors, auto-transformers, or filters or output reactors or dV/dt filters.

2.03 EQUIPMENT

A. Standards:
   1. Compliant with the standards referenced in this Section.

B. Ratings:
   1. Voltage: as indicated on the Drawings
   2. Continuous current: as required for the nameplate FLA of the driven load
   3. Short circuit current rating (SCCR): 65kA

C. Enclosure:
   1. Environmental Rating:
      a. Indoors (electrical rooms): NEMA 1
      b. Indoors (all other non-corrosive locations): NEMA 12
   2. Arrangement:
      a. Dead-front, metal enclosed
      b. Accessibility: front only
      c. Ventilation openings: front only
      d. Zero clearance required at the rear and sides of the enclosure.
      e. Maximum height: 90 inches
   3. Finish:
      a. Manufacturer's standard coating system over a rust-inhibiting primer.
      b. Color: ANSI 61 or 49 gray.
   4. Flanged disconnect handle:
      a. Allowing external operation of input circuit breaker
      b. Vertical ON/OFF operation with indication of current position.
      c. Interlocked to prevent enclosure from opening with the disconnect in the ON position.
      d. Provisions to accept up to (3) 3/8" padlocks to keep the disconnect in the OFF position.
   5. Hinged door with latch handle and padlockable hasp for each enclosure section

D. Architecture:
   1. Input protection:
      a. Circuit breaker disconnect
      b. Current-limiting input fuses where required by UL listing.
   2. Harmonic mitigation:
      a. VFDs driving loads 0-50HP:
         1) 6-pulse with equivalent AC input impedance of 5% that limits current total demand distortion (TDD) at the drive input terminals to less than 35%.
            a) DC chokes may be used to make up part of the equivalent input impedance but may not be used alone without an AC line reactor.
         2) 6-pulse with 3% impedance AC line reactor or split DC choke (impedance in both DC+ and DC- legs)
   3. Output:
      a. Pulse-width modulated (PWM) output via insulated gate bipolar transistors (IGBTs).
      b. Motor insulation protection:
         1) Provide equipment on the output of the VFD to mitigate the effects of the PWM output on motor insulation:
            a) Total cable distance from VFD to motor 0-150ft: no mitigation required
            b) Total cable distance from VFD to motor greater than 150ft and less than or equal to 300ft: load reactor (3% impedance)
            c) Total cable distance from VFD to motor greater 300ft: dV/dt filter

4. Motor overload protection:
    a. Electronic: selectable class 10, 20, or 30 trip curve
5. EMI/RFI filter: IEC 61800-3 Category C2 compliant
6. Circuit boards: conformally coated

E. Controls:
1. Door-mounted operator interface / keypad:
    a. Allowing start, stop, local/remote selection, speed adjustment, and programming of parameters.
    b. With digital display allowing indication of all monitored values and displaying alarms with identifying text.
2. Inputs, outputs, switches, pushbuttons, indicating lights, control relays, connections to external components, and logic as indicated on the Drawings.

F. Communications: Ethernet/IP port

G. Monitoring parameters:
1. Motor output:
    a. Frequency
    b. Voltage
    c. Current
    d. Power

H. Operational Capabilities:
1. Motor identification / auto-tune: automatically learn motor parameters by sensing response to drive outputs.
2. Catch a spinning load: from a de-energized output state, energize and control an already spinning motor.
3. Volts/Hz ramp with adjustable starting boost
4. Proportional integral derivative (PID) speed control
5. Adjustable output switching (carrier) frequency
6. Critical frequency avoidance:
    a. Minimum two set point ranges (skip frequencies) to prevent the VFD from operating the load continuously in a specific speed range to protect the driven equipment or process.

I. Protective Functions: configured to shunt trip the input circuit breaker for critical internal faults and freewheel stop and prevent starting for other faults
1. VFD overtemperature
2. VFD fault
3. Under/over voltage
4. Voltage phase balance / loss of phase
5. Stall and jam protection
6. Underload protection
7. Excessive start protection

2.04 COMPONENTS

A. Circuit Breakers:
   1. General:
      a. Stored energy type mechanism to provide quick-make, quick-break, trip-free operation.
      b. Interrupting rating: equal to or greater than the SCCR of the motor controller.
   2. Less than 225A Trip:
      a. Molded case, UL 489 listed
      b. Thermal magnetic trip

B. Pilot devices:
   1. In accordance with Section 26 09 16.

C. Wiring:
   1. Power Cables: UL listed, 90C rated copper wire.
   2. Control Cables: UL 1063 listed machine tool wire (MTW), 90C rated copper wire.
      a. Current transformer circuits: provide ring terminal terminations
   3. Identification: provide heat-shrink or locking tab type wire markers at each terminal to which the wire connects.
      a. The letters and numbers that identify each wire shall be machine printed on sleeves with permanent black ink with figures 1/8 inch high. Sleeves shall be white or yellow tubing and sized to fit the conductor insulation.

D. Control Power Transformers:
   1. Where indicated on the Drawings, provide control power transformers with 120VAC secondary for each motor controller unit:
      a. Primary fusing on both lines, secondary fusing on hot, grounded neutral.
      b. Sized to operate motor controller, all control loads, and all external components shown to be connected on the Drawings (including motor anti-condensation heaters, solenoids, motorized dampers, and instruments).
         1) Obtain loads for external components from the component suppliers.

2.05 ACCESSORIES

A. Nameplates:
   1. Provide nameplates with project-specific identifier(s) for each VFD in accordance with Section 26 05 00.

B. Lugs:
   1. Provide compression lugs rated 75 degree C and suitable for copper or aluminum wire for all incoming and outgoing phase and ground cables that do not terminate directly into a circuit breaker or drive output terminals.

C. Terminal blocks:
   1. Provide terminal blocks for all external control and signal wiring connections.
   2. Connection type: strap screw

3. Voltage rating: 600V
4. Current rating: 20A
5. Identification: integral marking strip with a unique number/identifier for each terminal. Numbers shall be machine printed and 1/8 inch high.

D. Drawing Pocket:
1. Provide a rigid plastic pocket on the interior of the enclosure door, with printed final copies of all the factory drawings for the motor controller in the pocket.
2. Manufacturers: Hammond PKT1212, Hoffman ADP2, Saginaw SCE-PP101201, approved equal

2.06 ACCESSORIES

A. Nameplates:
1. Provide nameplates with project-specific identifier(s) for each VFD in accordance with Section 26 05 00.

B. Lugs:
1. Provide compression lugs rated 75 degree C and suitable for copper or aluminum wire for all incoming and outgoing phase and ground cables that do not terminate directly into a circuit breaker or drive output terminals.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install VFDs in accordance with NEMA ICS 7.1 and the manufacturer's recommendations.

B. Install free-standing VFDs level and plumb on a 3-1/2" high reinforced concrete housekeeping pad in accordance with the Drawings/Details.

C. Install wall-mounted VFDs such that the centerline of the disconnect handle is at 48 inches above finished floor unless otherwise noted.

D. Anchor VFDs in accordance with the submitted anchorage details.

3.02 FIELD QUALITY CONTROL

A. Adjust settings of circuit breakers and protective relays to the values identified by the protective device coordination study performed under Section 26 05 73 prior to testing or energizing the MCC.

B. Test VFDs in accordance with Section 26 08 00.

C. Provide the services of a factory-trained manufacturer's representative to configure and assist with commissioning of the equipment, including the following activities:
1. Verify that physical installation (mounting, clearances, conduit and cable entry/terminations, etc.) and mechanical operation (circuit breaker operation, door swing, etc.) comply with the manufacturer's recommendations.

2. Configure each motor controller to match the nameplate characteristics and starting requirements of the driven equipment.
3. Implement and test the motor controller logic, inputs, outputs, network connections, local controls, field controls, and indicating lights on the unit control schematics (elementary diagrams).
4. Set class of adjustable overloads based on the recommendations of the driven equipment manufacturer, using the following defaults where the driven equipment manufacturer has no recommended values:
    a. General purpose pump and fan applications: Class 20
    b. Submersible pumps (wet-pit and dry-pit): Class 10
5. Perform a static motor identification / tuning operation with the motor de-coupled from the driven load to automatically detect motor parameters and adjust the VFD accordingly.
6. Set acceleration and deceleration ramp times, minimum and maximum speeds based on the needs of the driven equipment, Process Control Descriptions in Section 40 61 96, and optimizations to minimize stress on the motor and driven equipment. Where equipment needs or process control descriptions do not dictate otherwise, apply the following settings:
    a. Centrifugal pumping applications:
        1) Control Method: V/Hz
        2) Start: linear ramp, 15 seconds minimum
        3) Stop: linear ramp, 30 seconds minimum
        4) Emergency stop input activated: freewheel stop
        5) Loss of network communication: V/Hz ramp to freewheel, 30 seconds minimum
    b. Positive-displacement pump, fan, and blower and chopper pump applications:
        1) Control Method: sensorless vector
        2) Start: linear ramp, 15 seconds minimum
        3) Stop: freewheel stop
        4) Emergency stop: freewheel stop
        5) Loss of network communication: freewheel stop

END OF SECTION

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SECTION 40 05 01

PIPING SYSTEMS

PART 1 GENERAL

1.01 SUMMARY

A. This section specifies systems of process piping and general requirements for piping systems. Use the general requirements specified in this section with the more specific requirements listed in the Piping System Schedules (Section 40 05 02.00 through 40 05 02.99) and other referenced sections. Except where referenced specification sections specify alternate provisions, the requirements of this Section apply to all piping systems listed in Section 40 05 02.

1.02 REFERENCES

A. This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.

B. Unless otherwise specified, references to documents shall mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid (or on the effective date of the Agreement if there were no Bids). If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued. Where document dates are given in the following listing, references to those documents shall mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, discontinued or replaced.

Reference	Title
AASHTO M36/M36M	Metallic (Zinc or Aluminum) Coated Corrugated Steel Culverts and Underdrains
ANSI A13.1	Scheme for the Identification of Piping Systems
ANSI B1.20.1	Pipe Threads, General Purpose (Inch)
ANSI B16.1	Cast Iron Pipe Flanges and Flanged Fittings Class 25, 125, 250, and 800
ANSI B16.3	Malleable Iron Threaded Fittings Class 150 and 300
ANSI B16.5	Pipe Flanges and Flanged Fittings
ANSI B16.9	Factory-Made Wrought Steel Buttwelding Fittings
ANSI B16.11	Forged Steel Fittings, Socket Welding and Threaded
ANSI B16.12	Cast Iron Threaded Drainage Fittings
ANSI B16.22	Wrought Copper and Copper Alloy Solder Joint Pressure Fittings
ANSI B16.26	Cast Copper Alloy Fittings for Flared Copper Tubes
ANSI B31.1	Power Piping
ANSI B31.3	Chemical Plant and Petroleum Refinery Piping
ASME Section IX	Boiler and Pressure Vessel Code; Welding and Brazing Qualifications

Reference	Title
ASTM A47	Malleable Iron Castings
ASTM A53	Pipe, Steel, Black and Hot Dipped, Zinc-Coated Welded and Seamless
ASTM A74	Cast Iron Soil Pipe and Fittings
ASTM A105/A105M	Forgings, Carbon Steel, for Piping Components
ASTM A106	Seamless Carbon Steel Pipe for High-Temperature Service
ASTM A126	Standard Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings
ASTM A197	Cupola Malleable Iron
ASTM A234/A234M	Pipe Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and Elevated Temperatures
ASTM A312/A312M	Seamless and Welded Austenitic Stainless Steel Pipe
ASTM A403/A403M	Wrought Austenitic Stainless Steel Piping Fittings
ASTM A536	Ductile Iron Castings
ASTM A570/A570M	Hot-Rolled Carbon Steel Sheet and Strip, Structural Quality
ASTM B88	Seamless Copper Water Tube
ASTM C76	Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe
ASTM C296	Asbestos-Cement Pressure Pipe
ASTM C443-REV A	Standard Specification for Joints for Circular Concrete Sewer and Culvert Pipe, Using Rubber Gaskets
ASTM C564	Rubber Gaskets for Cast Iron Soil Pipe and Fittings
ASTM D1248	Polyethylene Plastics Molding and Extrusion Materials
ASTM D1784	Rigid Poly (Vinyl Chloride) (PVC) Compounds and Chlorinated Poly(Vinyl Chloride) (CPVC) Compounds
ASTM D1785	Poly (Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, and 120
ASTM D2241	Poly (Vinyl Chloride) (PVC) Plastic Pipe (SDR-PR)
ASTM D2513	Thermoplastic Gas Pressure Pipe, Tubing, and Fittings
ASTM D2665	Poly (Vinyl Chloride) (PVC) Plastic Drain, Waste, and Vent Pipe and Fittings
ASTM D2996	Filament-Wound Reinforced Thermosetting Resin Pipe
ASTM D3034	Standard Specification for Type PSM Poly (Vinyl Chloride) (PVC) Sewer Pipe and Fittings
ASTM D3261	Butt Fusion Polyethylene (PE) Plastic Fittings for Polyethylene (PE) Plastic Pipe and Tubing
ASTM D4174	Cleaning, Flushing, and Purification of Petroleum Fluid Hydraulic Systems
ASTM D4101	Propylene Plastic Injection and Extrusion Materials
ASTM F441	Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe, Schedules 40 and 80
AWWA C105	Polyethylene Encasement for Ductile-Iron Piping for Water and Other Liquids
AWWA C110	Ductile-Iron and Gray-Iron Fittings, 3 Inch Through 48 Inch, for Water and Other Liquids
AWWA C111	Rubber-Gasket Joints for Ductile-Iron and Gray-Iron Pressure Pipe and Fittings
AWWA C115	Flanged Ductile-Iron and Gray-Iron Pipe with Threaded Flanges
AWWA C151	Ductile-Iron Pipe, Centrifugally Cast in Metal Molds or Sand-Lined Molds, for Water or Other Liquids
AWWA C200	Steel Water Pipe 6 Inches and Larger
AWWA C205	Cement-Mortar Protective Lining and Coating for Steel Water Pipe–4 In. and Larger–Shop Applied
AWWA C206	Field Welding of Steel Water Pipe
AWWA C207	Steel Pipe Flanges for Waterworks Services–Sizes 4 In. through 144 In.

Reference	Title
AWWA C208	Dimensions for Fabricated Steel Water Pipe Fittings
AWWA C209	Cold-Applied Tape Coating for Special Sections, Connections, and Fittings for Steel Water Pipelines
AWWA C210	Liquid Epoxy Coating Systems for the Interior and Exterior of Steel Water Pipe
AWWA C214	Tape Coating Systems for the Exterior of Steel Water Pipelines
AWWA C301	Prestressed Concrete Pressure Pipe, Steel Cylinder Type, for Water and Other Liquids
AWWA C303	Reinforced Concrete Pressure Pipe–Steel Cylinder Type, Pretensioned, for Water and Other Liquids
AWWA C600	Installation of Ductile-Iron Water Mains and Their Appurtenances
AWWA C651	Disinfecting Water Mains
AWWA C900	Polyvinyl Chloride (PVC) Pressure Pipe, 4 Inches Through 12 Inches, for Water
AWWA M11	Steel Pipe--A Guide for Design and Installation
CISPI 301	Specification Data for Hubless Cast Iron Sanitary System with No-Hub Pipe and Fittings
FEDSPEC L-C-530B(1)	Coating, Pipe, Thermoplastic Resin or Thermosetting Epoxy
MIL-H-13528B	Hydrochloric Acid, Inhibited, Rust Removing
MIL-STD-810C	Environmental Test Methods
SAE J1227	Assessing Cleanliness of Hydraulic Fluid Power Components and Systems
UPC	Uniform Plumbing Code

1.03 DEFINITIONS

A. Pressure terms used in Section 40 05 01 and elsewhere in Division 40 are defined as follows:
   1. Maximum: The greatest continuous pressure at which the piping system operates.
   2. Test: The hydrostatic pressure used to determine system acceptance.

1.04 ADMINISTRATIVE REQUIREMENTS

A. Coordination:
   1. Pipe Sleeves: Coordinate placement of sleeves and penetrations in cast-in-place concrete with raceway, duct, and pipe penetrations prior to concrete placement. Coordinate placement of sleeves and wall penetration prior to construction of masonry building elements.
   2. Coordination required with the design of piping supports (hangers, guides, anchors, structural attachments, etc.), expansion joints, and expansion control and seismic restraints. Refer to sections 40 05 07, 40 05 07.13, and 40 05 07.16.
   3. To assure uniformity and compatibility of piping components, fittings and couplings for grooved end piping systems shall be furnished by the same manufacturers.

1.05 SUBMITTALS

A. Action Submittals:
   1. Procedures: Section 01 33 00.

2. A copy of this specification section, along with Sections 01 73 24, 40 05 07, 40 05 07.13 and 40 05 07.16, with addendum updates included, and all referenced and applicable sections, with addendum updates included, with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements. Check marks (✓) shall denote full compliance with a paragraph as a whole. If deviations from the specifications are indicated and, therefore requested by the Contractor, each deviation shall be underlined and denoted by a number in the margin to the right of the identified paragraph, referenced to a detailed written explanation of the reasons for requesting the deviation. The Construction Manager shall be the final authority for determining acceptability of requested deviations. The remaining portions of the paragraph not underlined will signify compliance on the part of the Contractor with the specifications. Failure to include a copy of the marked-up specification sections, along with justification(s) for any requested deviations to the specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration.
3. Submit piping layout drawings for all piping systems, including raceway, duct and other specified systems support. Indicate assembly details, location and placement of field welds, unions and flanges, fittings, valves, flushing connections, drains, sample taps, cathodic protection, seismic restraint system, expansion joints, guides, anchors, hangers, supports, and the provisions for thrust restraint, as well as any other pertinent details and appurtenances for all piping, including wall and floor penetrations, where applicable, in that area. Indicate location and clearances from structures and other utilities (ductwork, conduit, electrical tray, etc.). Include details of connections to new and existing equipment, piping and structures. Submit original layouts by the Contractor; photocopies of Contract Drawings are not acceptable. Identify the invert elevation of buried pipe at changes in slope, pipe crossings, and connections to structures on piping layout drawings in addition to providing coordinates for locating changes in horizontal alignment of buried pipe.
4. For each piping system (refer to Piping System Schedules in Section 40 05 02.00 through 40 05 02.99), submit document listing pipe, fittings, linings, coatings, valves, flexible connectors, expansion joints, couplings, bolts, gaskets, restraints, and other items provided for each applicable pipe size and category.
5. Welding: Prior to commencing any welding of steel or stainless steel pipe, supports, and/or structural attachments, provide a written description of welding techniques, including, but not limited to, materials, methods, and quality control. Identify differences in shop and field techniques. Indicate in the submittal that the welding technique has been reviewed for each piping service and certify that the technique is acceptable for the intended service condition (piping service defined in Section 40 05 02 and area exposure designation specified in Section 01 61 45). Written procedures to be stamped and sealed by a Professional Engineer registered in the State of Washington and qualified for welding design.

B. Informational Submittals:
1. Procedures: Section 01 33 00
2. Prior to the commencement of welding, submit current and complete documentation of the welder's qualifications.
3. Safety plans for pneumatic pressure testing.

1.06 QUALITY ASSURANCE

1. Review the drawings prior to installation of piping, conduit services, and fixtures. Identify any conflicts and cooperate with the Construction Manager to determine the adjustments necessary to resolve conflicts.
2. Confirm the routing of each section of pipeline with other services prior to commencement of installation. Advise the Construction Manager of any conflicts with existing services or services yet to be installed. Where necessary, amend the routing of pipework to avoid conflict and confirm with the Construction Manager.

1.07 DELIVERY, STORAGE, AND HANDLING

A. Procedures: Section 01 66 00.

B. Requirements:
1. Deliver pipe, fittings, and specials to site using loading methods which do not damage pipe or linings, or coatings.
2. Piping materials delivered to site will be clearly marked to indicate size, type, class/schedule and coatings.
3. Until ready for incorporation in the work, store on site as recommended by the piping materials manufacturer to prevent damage, undue stresses, or weathering.
4. Store materials at least 8 inches above ground. Provide sufficient supports to prevent undue bending.
5. Protect non-UV light inhibited plastic from sunlight.
6. Maintain refrigerant piping factory seals until ready for incorporation into the Work.
7. Cover openings in piping, and temporarily seal to protect from contamination.
8. Protect materials and equipment from damage due to environmental conditions. Use protective cover, and protect from surface water by elevating above floor or surrounding grade.
9. Protect unfinished work at end of each workday from damage, contamination and moisture by use of plugs, caps or covers.
10. Protect piping and valves from damage pending performance of system tests.
11. Use proper implements, tools, and facilities for the proper protection of the pipe. Exercise care in the installation so as to avoid damage to pipe, linings, and coatings.
12. Inspect each pipe and fitting prior to installation. Do not install damaged pipe or pipe with damaged protective coatings or linings.
13. Prevent entry of foreign matter during handling, assembling, and installation. Use compressed air, wire brush, solvent and other acceptable means to remove all foreign matter from inside of pipe prior to installation. Remove residual scale, dirt and other foreign matter from interior of piping before final connections are made.

PART 2 PRODUCTS

2.01 PIPING MATERIALS - GENERAL

A. Unless otherwise specified, piping materials, including pipe, gaskets, fittings, connection and joint assemblies, linings and coatings, shall be selected from those listed on the piping system specification sheets. Piping materials shall conform to detailed specifications for each type of pipe and piping appurtenance specified in other sections of Division 40.

2.02 PIPING IDENTIFICATION

A. Plastic Coding Markers for Exposed Piping:

1. Plastic markers for coding pipe shall conform to ANSI A13.1 and shall be as manufactured by W. H. Brady Company, Seton Name Plate Corporation, Marking Services Inc., or equal. Markers shall be the mechanically attached type that are easily removable; they shall not be the adhesive applied type. Markers shall consist of pressure sensitive legends applied to plastic backing which is strapped or otherwise mechanically attached to the pipe. Legend and backing shall be resistant to petroleum based oils and grease and shall meet criteria for humidity, solar radiation, rain, salt, fog and leakage fungus, as specified by MIL-STD-810C. Markers shall withstand a continuous operating temperature range of -40 degrees F to 180 degrees F. Plastic coding markers shall not be the individual letter type but shall be manufactured and applied in one continuous length of plastic.
2. Markers bearing the legends on the background colors specified in the PIPESPEC shall be provided in the following letter heights:

Outside Pipe Diameter,[1] Inches	Letter Height, Inches
Less than 1-1/2	1/2
1-1/2 through 3	1-1/8
Greater than 3	2-1/4

[1] *Outside pipe diameter shall include insulation and jacketing.*

3. In addition, pipe markers shall include uni- and bi-directional arrows in the same sizes as the legend. Legends and arrows shall be white on blue or red backgrounds and black on other specified backgrounds.

2.03 VALVES

A. Valves of the same size and service shall be provided by a single valve manufacturer. Packing shall be nonasbestos material. Actual length of valves shall be within 1/16 inch (plus or minus) of the manufacturer's specified length.

B. Flanges shall meet the requirement of ANSI B16.5. Push-on and mechanical joints shall meet the requirements of AWWA C111.

C. Valve operators are specified in Sections 40 05 57.13.

2.04 BONDING JUMPERS

A. Provide plated, flexible copper braid jumpers with unplated copper ferrules for attachment to pipe flanges, rated for a 100 amp minimum. Provide Burndy Electrical, Type B series, or Approved Equal, and sufficient conductive, anti-oxidant compound (Burndy Electrical Penetrox series or Approved Equal) to protect ferrules.

2.05 JOINTS – GENERAL

A. Provide joints for disassembly within 3.0 ft of any connection to equipment, on both sides of structural penetrations, and within 2.0 ft of all threaded end valves.

B. Unless otherwise specified on the Drawings or in equipment specifications, adapt all equipment connections to a flanged connection compatible with the connected piping system.

C. Flexible Joints at Structural Joint Crossings: Provide a flexible joint (or joints) on all piping crossing structural joints.

2.06 FLANGES AND OTHER COUPLINGS

A. General requirements for flanges are as follows:
   1. Where raised-face and flat flanges are provided for connection, reface the raised-face flanges. Flange face to be flush with flat-faced companion flanges on flat-faced valve or equipment flanges.
   2. Provide flat-faced flanges on each side of butterfly valves.
   3. For steel piping, provide weld neck flanges on both sides of wafer or lug body valves.

B. Slip-on flanges that are attached to a pipe by means of set screws and gaskets (uni-flange, etc.) are not acceptable.

2.07 FITTINGS – GENERAL

A. Fittings are specified in the PIPESPEC.

B. Provide eccentric reducers in horizontal lines with the flat side on top, unless specified otherwise on the Drawings (e.g., flow meters in horizontal runs requiring submergence).

C. Provide concentric reducers in vertical lines, unless otherwise specified on the Drawings.

D. Provide reducers upstream and downstream of flow measurement devices to adapt line size to the specified flow measurement device dimension. Coordinate with the specific instrument requirements.

E. Provide long radius (greater than or equal to 1.5 x nominal diameter) elbows unless otherwise specified on the Drawings or PIPESPECS.

2.08 COUPLING GASKET MATERIALS

A. For flat faced flanges, use full-face gaskets. For raised-face flanges, use ring type gaskets. Conform to ANSI B16.21.

B. Refer to the PIPESPEC for the specified gasket material. Material designations used in the detailed pipe specification sheets are as follows:
   1. EPDM: ethylene-propylene-diene-terpolymer 70 durometer
   2. Neoprene: neoprene (black) 70 durometer
   3. Nitrile: nitrile (Buna N)
   4. SBR: Styrene-butadiene (red)
   5. Natural rubber: natural rubber
   6. Compressed synthetic fibers (Kevlar): ASTM F104 (F712400), and neoprene binder: 1.7 MPa (ASTM F152), 0.2 mL/h Leakage Fuel A (ASTM F37)
   7. Compressed synthetic fibers (Kevlar): ASTM F104 (F712400) and SBR binder: 1.7 MPa (ASTM F152), 0.1 mL/h Leakage Fuel A (ASTM F37)
   8. Gylon - Type 1: Garlock Style 3500: 1.35 MPa (ASTM F152), 0.22 mL/h Leakage Fuel A (ASTM F37)
   9. Gylon - Type 2: Garlock Style 3510: 1.35 MPa (ASTM F152), 0.04 mL/h Leakage Fuel A (ASTM F37)
   10. CPE - Chlorinated Polyethylene
   11. Spiral-wound: per ASME B16.20, rated to 1200-degree Fahrenheit Flexitallic SS316L or approved equal
   12. PTFE bonded EPDM, full-face gaskets
   13. Viton/FKM – Fluoroelastomer, 75 Durometer

2.09 DISSIMILAR METAL CONNECTIONS

A. Where dissimilar metals are to be connected, provide dielectric fittings and/or isolating flanges, including bolt sleeves and washers.

2.10 CATHODIC PROTECTION

A. Provide cathodic protection of piping, pipe fittings, and appurtenances, where specified on the Drawings.

2.11 STRUCTURAL ELEMENT PENETRATIONS

A. Penetrations through structural elements are referenced to a custom detail or Standard Detail. Where a penetration detail is not specified, conform to the Standard Detail relevant to the type of structure, exposure, and type of pipe.

B. Provide pipe sleeves capable of supporting the loads applied during placement of concrete or during block work erection.

PART 3 EXECUTION

3.01 INSTALLATION

A. Location:
   1. Piping shall be provided as specified except for adjustments to avoid architectural and structural features and shall be coordinated with electrical construction.

B. Piping Sizes:

1. Where the size of piping is not specified, the Contractor shall provide piping of the sizes required by UPC. Unless specified otherwise, small piping (less than 1 inch in diameter) required for services not described by UPC shall be 1/2 inch.

C. Pipe Support, Anchorage and Seismic Bracing:

1. General: Piping shall be supported by anchor brackets, guides, saddles or hangers. Acceptable types of supports, guides, saddles, hangers and structure attachments for general pipe support, expansion/ contraction and for seismic bracing, as well as anchorage details, are shown on the drawings. Minimum spacing shall be as specified for supports and for seismic bracing. Where a specific type of support or anchorage is indicated on the drawings, then only that type shall be used there. Piping shall be vertically supported by anchor brackets, guides, saddles or hangers and shall be seismically braced where indicated to resist lateral load. Supports shall be provided on each run at each change of direction. Pipe supports shall be hot-dip or mechanically galvanized. Unless otherwise specified, existing pipes and supports shall not be used to support new piping.
2. Piping Connections to Machines: Piping at machine connections shall be aligned in all planes to permit insertion of bolts at bolted connections or coupling screwed connections without using jacks, come-a-longs or other mechanical means to align field piping with the connections at the machines. Bolts shall not be forced into mating flange bolt holes and shall be capable being withdrawn using finger pressure alone. The use of 'dutchmen' mitered sections or similar specials to achieve the required alignment with machine connections is strictly prohibited.

D. Equipment Connection Fittings

1. Where shown, equipment connection fittings as specified in Section 40 05 06.16 shall be provided between field piping systems and equipment inlet and outlet connections.

E. Flexibility

1. Unless otherwise specified, piping passing from concrete to earth shall be provided with two pipe couplings or flexible joints as specified in Section 40 05 06.16.

3.02 PIPING IDENTIFICATION

A. Pipe Coding:

1. After application of the specified coating and insulation systems, exposed piping, interior and exterior, and piping in ceiling spaces, pipe trenches, pipe chases and valve boxes shall be identified with plastic markers as specified in paragraph 2.02 Plastic Coding Markers. Legend markers and directional arrows shall be located at each side of walls, floors and ceilings, at one side of each piece of equipment, at piping intersections, and at approximately 50-foot centers.

3.03 VALVE IDENTIFICATION

A. Stainless steel tags bearing the specified valve number stamped in 1/4-inch high letters shall be installed on valve flanges in a position visible from floor level. Flangeless valves 8 inches in diameter and larger shall have tags attached to the valve body by self-tapping corrosion resistant metal screws. Flangeless valves 6 inches in diameter and smaller shall have tags attached to the valve stem by stainless steel wire. Wire shall be 0.063 inch minimum.

3.04 TESTING

A. General:
   1. Upon completion of piping, but prior to application of insulation on exposed piping, the Contractor shall test the piping systems. Pressures, media and test durations shall be as specified in the PIPESPEC. Equipment which may be damaged by the specified test conditions shall be isolated. Testing shall be performed using calibrated test gages and calibrated volumetric measuring equipment to determine leakage rates. Each test gage shall be selected so that the specified test pressure falls within the upper half of the gage's range. Unless otherwise specified, the Contractor shall notify the Construction Manager 24 hours prior to each test.
   2. Unless otherwise specified, testing, as specified herein, shall include existing piping systems which connect with new pipe systems. Existing pipe shall be tested to the nearest existing valve. Any piping which fails the test shall be repaired. Repair of existing piping will be considered and paid for as extra work.

B. Gas, Air, and Vapor Systems:
   1. Unless otherwise specified, the testing medium for other gas, air and vapor systems shall be as follows:

Pipeline Size	Specified Test Pressure	Testing Medium
2 inch and smaller	75 psi or less	Air or water
2 inch and smaller	Greater than 75 psi	Water
Greater than 2 inch	3 psi or less	Air or water
Greater than 2 inch	Greater than 3 psi	Water

   2. The allowable leakage rate for hazardous gas systems, insulated systems, and systems tested with water shall be zero at the specified test pressure throughout the specified test period. Hazardous gas systems shall include sulfur dioxide, chlorine, propane, sludge gas and natural gas systems.
   3. The allowable leakage rate for other systems tested with air shall be based on a maximum pressure drop of 5 percent of the specified test pressure for the duration of the period. Prior to starting a test interval using air, the air shall be at ambient temperature and specified test pressure.

C. Liquid Systems:

1. Leakage shall be zero at the specified test pressure throughout the specified duration for the following systems: exposed piping, buried insulated piping, and buried or exposed piping carrying liquid chemicals. Unless otherwise specified, leakage from other buried liquid piping systems shall be less than 0.02 gallon per hour per inch diameter per 100 feet of buried piping.

D. Drains:

1. Drain systems, other than pumped drain systems, shall be tested in accordance with UPC.

3.05 CLEANING AND FLUSHING

A. General:

1. Piping systems shall be cleaned following completion of testing and prior to connection to operating, control, regulating or instrumentation equipment. The Contractor may, at his option, clean and test sections of buried or exposed piping systems. Use of this procedure, however, will not waive the requirement for a full pressure test of the completed system. Unless specified otherwise, piping 24 inches in diameter and smaller shall first be cleaned by pulling a tightly fitting cleaning ball or swab through the system. Piping larger than 24 inches in diameter may be cleaned manually or with a cleaning ball or swab.

B. Temporary Screens:

1. Upon completion of the cleaning, the Contractor shall connect the piping systems to related process equipment. Temporary screens, provided with locator tabs which remain visible from the outside when the screens are in place, shall be inserted in pipelines at the suction of pumps and compressors in accordance with the following table:

Equipment Suction or Piping Size, Inches	Maximum Screen Opening, Inches
0 –1	1/16
1-1/4 – 3	1/4
3-1/2 – 6	1/2
Over 6	1

2. The Contractor shall maintain the screens during testing, initial start-up, and initial operating phases of the commissioning process. In special cases, screens may be removed as required for performance tests. The Contractor shall remove the temporary screens and make the final piping connections after the screens have remained clean for at least 24 consecutive hours of operation. Systems handling solids are exempted.

C. Gas and Air Systems:

1. Unless otherwise specified, gas and air system piping 6 inches in diameter and smaller shall be blown out, using air or the testing medium specified. Piping larger than 6 inches shall be cleaned by having a swab or "pig" drawn through the separate reaches of pipe. After connection to the equipment, it shall then be blown out using the equipment. Upon completion of cleaning, the piping shall be drained and dried with an airstream. Sludge gas, natural gas and propane systems shall be purged with nitrogen and a nitrogen pad maintained at 10 psi until put in service.

D. Liquid Systems:

1. After completion of cleaning, liquid systems, unless otherwise specified, shall be flushed with clean water. With temporary screens in place, the liquid shall be circulated through the piping system using connected equipment for a minimum period of 15 minutes and until no debris is collected on the screens.

E. Potable Water Systems:

1. Potable water piping systems shall be flushed and disinfected in accordance with AWWA C651.

END OF SECTION

SECTION 40 05 02

PIPING SYSTEM SCHEDULES

PART 1 GENERAL

1.01 SUMMARY

A. This section specifies a Piping System Schedule for each Process Service. Each Piping System Schedule specifies piping system materials for groups of similar process piping services.

B. The table in paragraph 1.01C lists process services and the corresponding Piping System Schedule that specifies piping system material requirements for the associated process piping service. See Part 4 for Piping System Schedules that define materials for piping services.

C. Piping System Schedule assignments are listed in the following table:

Process Service Identifier	Process Service	Piping System Schedule	Fluid Category	Pipe Marker Background Color
AHP	Air, High Pressure	40 05 02.03	Air	Blue
DB	Dewatered Biosolids	40 05 02.53	Sludge	Green
DS	Digested Sludge	40 05 02.53	Sludge	Green
FA	Foul Air	40 05 02.83	Combustible	Brown
F	Filtrate	40 05 02.43	Sludge	Green
PD	Process Drain	40 05 02.43	Drain/Vent	Green
PO	Polymer Solution	40 05 02.63	Chemical	
SPF	Screw Press Feed	40 05 02.53	Sludge	Green
3W	Plant Effluent Water	40 05 02.29	Water	Green
HPHW	High Pressure Hot Water	40 05 02.30	Water	Red

1.02 QUALITY ASSURANCE

A. References:

1. This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section prevail.

Reference	Title
ASME B1.20.1	Pipe Threads, General Purpose
ASME B16.1	Cast Iron Pipe Flanges and Flanged Fittings, Class 25, 125, and 250
ASME B16.3	Malleable Iron Threaded Fittings Class 150 and 300
ASME B16.5	Pipe Flanges and Flanged Fittings
ASME B16.9	Factory-Made Wrought Steel Butt Welding Fittings

Reference	Title
ASME B16.11	Forged Steel Fittings, Socket Welding and Threaded
ASME B16.12	Cast Iron Threaded Drainage Fittings
ASME B16.18	Cast Copper Alloy Solder Joint Pressure Fittings
ASME B16.22	Wrought Copper and Copper Alloy Solder Joint Pressure Fittings
ASME B16.26	Cast Copper Alloy Fittings for Flared Copper Tubes
ASME B31.1	Power Piping
ASME B31.3	Process Piping
ASME B31.9	Building Services Piping
ASME B32	Solder Metal
ASME B36.10	Welded and Seamless Wrought Steel Pipe
ASME B36.19	Stainless Steel Pipe
ASME B1.1	Unified Inch Screw Threads
ASME Section IX	Boiler and Pressure Vessel Code; Welding and Brazing Requirements
ASTM A47	Malleable Iron Castings
ASTM A53	Pipe, Steel, Black and Hot Dipped, Zinc Coated Welded and Seamless
ASTM A74	Cast Iron Soil Pipe and Fittings
ASTM A105/A105M	Forgings, Carbon Steel, for Piping Components
ASTM A106	Seamless Carbon Steel Pipe for High Temperature Service
ASTM A126	Grey-Iron Castings for Valves, Flanges, and Pipe Fittings
ASTM A135	Electric-Resistance-Welded Steel Pipe
ASTM A139	Electric-Fusion (ARC)-Welded Steel Pipe (NPS 4 and Over)
ASTM A167	Stainless Steel and Heat-Resisting Chromium-Nickel Steel Plate
ASTM A181/181M	Forgings, Carbon Steel, for General Purpose Piping
ASTM A182/182M	Forged or Alloy Steel Pipe Flanges, Forged Fittings, and Valves and Parts for High-Temperature Service
ASTM A193/193M	Alloy Steel and Stainless Steel Bolting Materials for High Temperature Service High Pressure Service and Other Special Purpose Applications
ASTM A194/194M	Carbon and Alloy Steel Nuts for Bolts for High Pressure and High Temperature Service or High Temperature Service, or Both
ASTM A197	Cupola Malleable Iron
ASTM A234/A234M	Pipe Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and Elevated Temperatures
ASTM A240	Heat-Resisting Chromium and Chromium-Nickel Stainless Steel Plate, Sheet and Strip for Pressure Vessels
ASTM A269	Seamless and Welded Austenitic Stainless Steel Tubing for General Service
ASTM A276	Stainless and Heat-Resisting Steel Bars and Shapes
ASTM A307	Carbon Steel Bolts and Studs, 60 000 psi Tensile Strength
ASTM A312/312M	Seamless and Welded Austenitic Stainless Steel Pipe
ASTM A320/320M	Alloy Steel Bolting Materials for Low-Temperature Service
ASTM A403/A403M	Wrought Austenitic Stainless Steel Piping Fittings
ASTM A409/A409M	Welded Large Diameter Austenitic Steel Pipe for Corrosive or High Temperature Service
ASTM A480/A480M	General Requirements for Flat-Rolled Stainless and Heat-Resisting Steel Plate, Sheet, and Strip
ASTM A480/A480M	General Requirements for Flat-Rolled Stainless and Heat-Resisting Steel Plate, Sheet, and Strip
ASTM A536	Ductile Iron Castings
ASTM A563	Carbon and Alloy Steel Nuts

Reference	Title
ASTM A774/A774M	As-Welded Wrought Austenitic Stainless Steel Fittings for General Corrosive Service at Low and Moderate Temperatures
ASTM A778	Welded, Unannealed Austenitic Stainless Steel Tubular Products
ASTM A1011/A1011M	Standard Specification for Steel, Sheet and Strip, Hot-Rolled, Carbon, Structural, High- Strength Low-Alloy, High-Strength Low-Alloy with Improved Formability, and Ultra-High Strength
ASTM B75	Seamless Copper Tube
ASTM B88	Seamless Copper Water Tube
ASTM B584	Copper Alloy Sand Castings for General Applications
ASTM C76	Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe
ASTM C564	Rubber Gaskets for Cast Iron Soil Pipe and Fittings
ASTM C361	Reinforced Concrete Low-Head Pressure Pipe
ASTM C443	Joints for Concrete Pipe and Manholes, Using Rubber Gaskets
ASTM C478	Circular Precast Reinforced Concrete Manhole Sections
ASTM D638	Test Method for Tensile Properties of Plastics
ASTM D792	Test Method for Specific Gravity and Density of Plastics by Displacement
ASTM D1248	Standard Specification for Polyethylene Plastics Extrusion Materials for Wire and Cable
ASTM D1784	Rigid Poly (Vinyl Chloride) (PVC) Compounds and Chlorinated Poly (Vinyl Chloride) (CPVC) Compounds
ASTM D1785	Poly (Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, and 120
ASTM D2241	Poly (Vinyl Chloride) (PVC) Plastic Pipe (SDR-PR)
ASTM D2466	Poly (Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 40
ASTM D2467	Poly (Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 80
ASTM D2513	Thermoplastic Gas Pressure Pipe, Tubing, and Fittings
ASTM D2564	Solvent Cements for Poly (Vinyl Chloride) (PVC) Plastic Pipe and Fittings
ASTM D2665	Poly (Vinyl Chloride) (PVC) Plastic Drain, Waste, and Vent Pipe and Fittings
ASTM D2996	Filament-Wound Reinforced Thermosetting Resin Pipe
ASTM D3034	Type PSM Poly(Vinyl Chloride) (PVC) Sewer Pipe and Fittings
ASTM D3212	Joints for Drain and Sewer Plastic Pipes using Flexible Elastomeric Seals
ASTM D3261	Butt Fusion Polyethylene (PE) Plastic Fittings for Polyethylene (PE) Plastic Pipe and Fittings
ASTM D3350	Polyethylene Plastics Pipe and Fittings Materials
ASTM D4101	Propylene Plastic Injection and Extrusion Materials
ASTM D4174	Cleaning, Flushing, and Purification of Petroleum Fluid Hydraulic Systems
ASTM D4894	Standard Specification for Polytetrafluoroethylene (PTFE) Granular Molding and Ram Extrusion Materials
ASTM D4895	Standard Specification for Polytetrafluoroethylene (PTFE) Resin Produced from Dispersion
ASTM F441	Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe, Schedules 40 and 80
ASTM F894	Standard Specification for Polyethylene (PE) Large Diameter Profile Wall Sewer and Drain Pipe
AWWA C104	Cement–Mortar Lining for Ductile-Iron Pipe and Fittings
AWWA C105	Polyethylene Encasement for Ductile-Iron Piping for Water and Other Liquids
AWWA C110	Ductile-Iron and Grey-Iron Fittings, 3 Inch Through 48 Inch, for Water and Other Liquids
AWWA C111	Rubber-Gasket Joints for Ductile-Iron and Grey-Iron Pipe and Fittings
AWWA C115	Flanged Ductile-Iron and Grey-Iron Pipe with Threaded Flanges

Reference	Title
AWWA C150	Thickness Design of Ductile-Iron Pipe
AWWA C151	Ductile-Iron Pipe, Centrifugally Cast in Metal Molds or Sand-Lined Molds, for Water and Other Liquids
AWWA C153	Ductile-Iron Compact Fittings
AWWA C200	Steel Water Pipe, 6 Inches and Larger
AWWA C203	Coal Tar Protective Coatings and Linings for Steel Water Pipelines - Enamel and Tape - Hot Applied
AWWA C205	Cement-Mortar Protective Lining and Coating for Steel Water Pipe - 4 Inches through 144 Inches
AWWA C206	Field Welding of Steel Water Pipe
AWWA C207	Steel Pipe Flanges for Waterworks Services - Sizes 4 Inch Through 144 Inch
AWWA C208	Dimensions for Fabricated Steel Water Pipe Fittings
AWWA C209	Cold-Applied Tape Coating for Special Sections, Connections, and Fittings for Steel Water Pipelines
AWWA C210	Coal-Tar Epoxy Coating System for the Interior and Exterior of Steel Water Pipe
AWWA C214	Tape Coating Systems for the Exterior of Steel Water Pipelines
AWWA C222	Polyurethane Coatings for the Interior and Exterior of Steel Water Pipe and Fittings
AWWA C301	Coupling for Use in Connection with Hubless Cast Iron Soil Pipe and Fittings for Sanitary and Storm Drain, Waste, and Vent Piping Applications
AWWA C303	Reinforced Concrete Pressure Pipe - Steel Cylinder Type, Pretensioned, for Water and Other Liquids
AWWA C600	Installation of Ductile-Iron Water Mains and their Appurtenances
AWWA C606	Grooved and Shouldered Joints
AWWA C651	Disinfecting Water Mains
AWWA C900	Polyvinyl Chloride (PVC) Pressure Pipe, 4 Inches Through 12 Inches, for Water
AWWA M11	Steel Pipe - A Guide for Design and Installation
CISPI 301	Specification Data for Hubless Cast Iron Sanitary System with No-Hub Pipe and Fittings
EJMA STDS	Standards of Expansion Joint Manufacturers' Association, Edition No. 6
FSA	Fluid Sealing Association Technical Handbook, Rubber Expansion Joint Division
FEDSPEC, L-C-530B(1)	Coating, Pipe, Thermoplastic Resin or Thermosetting Epoxy
MIL-H-13528B	Hydrochloric Acid, Inhibited, Rust Removing
MIL-S-8660C	Silicone Compound
MIL-STD-810C	Environmental Test Methods
MSS SP-25	Standard Marking System for Valves, Fittings, Flanges and Unions
MSS SP-43	Wrought Stainless Steel Butt Welding Fittings
MSS SP-97	Integrally Reinforced Forged Branch Outlet Fittings – Socket Welding, Threaded, and Buttwelding Ends
MSS SP-114	Corrosion Resistant Pipe Fittings Threaded and Socket Welding Class 150 and 1000
NSF/ANSI 61:	Drinking Water System Components – Health Effects
SSPC	Society for Protective Coatings
SAE J1227	Assessing Cleanliness of Hydraulic Fluid Power Components and Systems

1.03 DEFINITIONS

A. Terminology used in this Section conforms to the following definitions:

B. Pipe Connections and Joints:
   1. BABS – Bell and Ball Spigot
   2. BAS – Bell and Spigot
   3. BFW – Butt Fusion Weld
   4. BSS – Bolted Split Sleeve Coupling
   5. BW – Butt Weld
   6. BSW – Butt-Strap Weld
   7. CGRV – Cut (or Cast) Grooved End Coupling
   8. CPLG – Coupling
   9. CPO – Compression Type Push-On
   10. CPRSN – Compression
   11. DLW – Double Lap Weld (Bell and Spigot)
   12. EFSW - Electro-Fusion Socket Weld
   13. FLG – Flanged
   14. FLRD – Flared
   15. FP – Full Penetration
   16. FSW – Fusion Socket Weld
   17. HAS – Hub and Spigot, Compression (Cast Iron Soil Pipe)
   18. HBLS - Shielded Hubless (Cast Iron Soil Pipe)
   19. HGRV – HDPE Groove Coupling
   20. HLF CPLG – Half Coupling
   21. HPEG – HDPE Plain End with Gripping Teeth
   22. HXGT - HDPE by Grooved End Transition
   23. LR ELL – Long Radius Elbow
   24. MJ – Mechanical Joint
   25. PGRV - Proprietary Groove Coupling
   26. PO – Push-on
   27. RBAS – Restrained (Lap Welded) Bell and Spigot with O-ring rubber gasket
   28. RGRV – Rolled Grooved End Coupling
   29. RJC – Ring Joint Coupling
   30. RMJ – Restrained Mechanical Joint
   31. RPO – Restrained Push-On joint
   32. SLV – Solvent Weld
   33. SLDR – Solder or Brazing
   34. SLW – Single Lap Weld (Bell and Spigot)
   35. SR ELL – Short Radius Elbow
   36. SW – Socket Weld

37. THD – Threaded
38. UN – Union

C. Flanges:
   1. FF – Full Face
   2. LF – Loose Flange
   3. LJ – Lap Joint
   4. LWN – Long Weld Neck
   5. RF – Raised Face
   6. SO – Slip-On
   7. THD – Threaded
   8. WN – Weld Neck

D. Materials:
   1. DI – Ductile Iron
   2. RCP – Reinforced Concrete Pipe
   3. RCP-LHP – Reinforced Concrete Low Head Pressure Pipe
   4. SS – Stainless Steel
   5. SV – Service (Cast Iron Soil Pipe available with SV rating or XH, extra heavy, rating)

E. Welding:
   1. FP – Full Penetration
   2. SML – Seamless
   3. WLD – Welded

F. Other:
   1. CFT - Cured Film Thickness
   2. DFT – Dry Film Thickness
   3. Dim – Dimensions
   4. M or E Pipe – Matches or exceeds rating of connecting pipe
   5. Thk – Thickness
   6. Sch – Schedule
   7. Std – Standard
   8. STD – Standard Weight or Standard

PART 2 PRODUCTS

2.01 MATERIALS

A. Pipe size (nominal diameter) and the Process Service Identifier for the contents of the pipeline are specified in pipe line labels on the drawings.

B. Provide piping system materials and components per the Piping System Schedule assigned for the specified process service and pipe size.

C. The Rating column in the Piping System Schedule specifies the minimum acceptable pressure rating or wall thickness for the component of the piping system.

PART 3 NOT USED

PART 4 SCHEDULES

4.01 PIPESPEC SYSTEM SHEETS/DETAILED PIPING SPECIFICATION SHEETS.

A. Piping System Schedules follow this Section. Piping System Schedules are assigned a Section number in the range from 40 05 02.00 through 40 05 02.99.

END OF SECTION

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Section 40 05 02.03

Piping System Schedule, Process Air (Carbon Steel)

Process Service	Air, High Pressure							
Process Service Identifier	***AHP***							

General Requirements

A. **Testing Requirements: Pressure: 20 psig. Duration: 120 min. Medium: Air**

B. Comply with the provisions of Section 40 05 01 in addition to the requirements specified herein. Refer to Section 40 05 02 for definitions of abbreviations and acronyms used in this schedule.

C. Full-Faced flanges mated with raised face flanges are not permitted.

D. Mating flanges for pipe shall be of the same Standard, Class, and Series. Mating flanges at valves and equipment shall have specified rating and matching drilling pattern.

E. Pipe Threads per ASME B1.20.1.

F. Match metal alloy/grade/type for any metal welded to pipe or fittings. (e.g. Do not weld carbon steel to stainless steel; weld Type 316L to Type 316L pipe material.)

Key Notes (Indexed to Key Notes in the Piping System Schedule)

1. Bolt length per ASME B16.5 plus three additional threads. Hex head bolt dimensions per ASME B18.2.1. Class 2A standard coarse series threads per ASME B1.1, standard coarse thread series. Hex nut dimensions per ASME B18.2.2 (Heavy Hex). Class 2B standard coarse series threads per ASME B1.1.
2. Apply Anti-seize to stainless steel bolts before turning nut on flange bolts.
3. Provide Long Radius Elbows. Provide full flow fittings. Segmentally welded elbows are not acceptable.
4. Provide long radius five cut mitered elbows for segmentally welded fittings.
5. Stainless steel stub end per MSS SP-43 Type A or Type B for use with Lap Joint flanges. Stub end dimensions and materials to match pipe. Fillet radius of stub ends compatible with inner corner radius of backing flange bore.
6. For Headspace, Process Corrosive, and Submerged area exposures, use stainless steel flanges with stainless steel bolts and nuts.
7. Factory coat carbon steel/ductile iron backing ring flanges with Liquid Epoxy per AWWA C210, 16 mils DFT, minimum.
8. Provide stainless steel flange bolts, nuts, and washers with stainless steel flanges.
9. Insulate for Energy Conservation in Indoor Dry and Indoor Wet area exposures. Insulate for Personnel Protection in other area exposures.
10. Provide weld neck flanges on both sides of wafer, lug body, or flanged valves.

Section 40 05 02.03 — Piping System Schedule, Process Air (Carbon Steel)

Process Service	Air, High Pressure							
Process Service Identifier	***AHP***							

Indoor Dry, Indoor Wet, Outdoor (Exposed)

Component	Line Size, in	Material	Rating	Conn./Joints	Spec Section	Key Notes
Pipe	1/8 thru 2-1/2	Steel: ASTM A53, Gr B, Type E or Type S, galvanized, Dim. Per ASME B36.10	Sch. 40	THD	40 05 24	
Lining for Pipe & Fittings	1/8 thru 2-1/2	None	—	—	—	
	Valves	Manufacturer's Standard Primer or Primer and Finish Coating: Factory Applied	—	—	—	
		High Temperature Service Epoxy: Field Applied Finish Coat	Min. 15 mils DFT	—	40 05 24	
Fittings	1/8 thru 2-1/2	Malleable Iron: ASTM A47 or ASTM A197, galvanized, Dim. per ASME B16.3	Class 150	THD	40 05 24	3
		Forged Steel: ASTM A105, galvanized Dim. per ANSI B16.11		THD	40 05 24	3
		Fabricated Steel Grooved End: ASTM A53, Gr B, Type E or Type S, Dim. per manufacturer's standard	Sch. 40	CGRV, RGRV	40 05 24	3
		Wrought Steel: ASTM A234-WPB, Dim. per ASME B16.9	Sch 40	FLG	40 05 24	3
Taps	1/8 thru 2-1/2	Malleable Iron Tee: ASTM A47 or ASTM A197, galvanized, Dim. per ASME B16.3	Class 150	THD	40 05 24	
		Forged Steel Tee: ASTM A105, galvanized, Dim. per ANSI B16.11	Class 300	THD	40 05 24	
	3 thru 72	Forged Steel Threadolet or Half Coupling: ASTM A105, Dim. per ANSI B16.11	Class 3000	FP Beveled Fillet Weld	40 05 24	
Grooved Coupling	3 thru 24	Rigid Coupling: ASTM A536 Gr 65-45-12, Groove Dim. per AWWA C606	M or E Pipe	CGRV, RGRV	40 05 24	
		Flexible Coupling: ASTM A536 Gr 65-45-12, Groove Dim. per AWWA C606		CGRV, RGRV	40 05 24	
FLG Bolts, nuts and hardware	All	Carbon Steel Bolts: ASTM A307 Gr A. Carbon Steel Nuts: ASTM A563, 1/4" thru 1-1/2" use Gr A hex nuts, 1-5/8" thru 3" use Gr A heavy hex nuts	All	—	—	1
Flange gaskets	3 thru 10	Viton/FKM	1/16 in Thk.	FLG	40 05 01	
Mechanical Coupling Gaskets	2-1/2 thru 30	Viton/FKM	—	—	—	
Compression and Push-On Gaskets	None	None	—	—	—	

Section 40 05 02.03 — Piping System Schedule, Process Air (Carbon Steel)

Process Service	Air, High Pressure							
Process Service Identifier	***AHP***							

Indoor Dry, Indoor Wet, Outdoor (Exposed)

Component	Line Size, in	Material	Rating	Conn./Joints	Spec Section	Key Notes
Valves	1/4 thru 2	Ball: Bronze Body/Ball, 40 05 63.02	—	THD	40 05 60	
		Globe: Bronze, 40 05 66.01		THD	40 05 60	
		Lift Check: Bronze, 40 05 65.02		THD	40 05 60	
Insulation	1/2 thru 36	Fiberglass or Mineral Wool: ASTM C547-Type I Grade A, Medium Temperature Range, Personnel Protection and Energy Conservation, Aluminum Jacket/Covers	1 in. Thk.	—	40 42 00	9

END OF SECTION

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Schedule 40 05 02.29 - Plant Utility Water, Medium Pressure

Process Service	Plant Effluent Water				
Process Service Identifier	3W				

Test Conditions

Pressure (psig)	Duration (min.)	Medium
350	120	Water

General Requirements

1. Full-Faced flanges mated with raised face flanges are not permitted.
2. Mating flanges for pipe shall be of the same Standard, Class and Series. Mating flanges at valves and equipment shall have specified rating and matching drilling pattern.
3. Threads per ASME B1.20.1.
4. Match metal alloy/grade/type for any metal welded to pipe or fittings. (e.g. Do not weld carbon steel to stainless steel; weld Type 316L to Type 316L pipe material.)

Notes:

1. Flange bolt length per ASME B16.5 plus three additional threads. Hex head bolt dimensions per ASME B18.2.1. Class 2A standard coarse series threads per ASME B1.1, standard coarse thread series. Hex nut dimensions per ASME B18.2.2 (Heavy Hex). Class 2B standard coarse series threads per ASME B1.1.
2. Provide Long Radius Elbows. Provide full flow fittings. Segmentally welded fittings are not acceptable.
3. Provide long radius five cut mitered elbows for segmentally welded fittings.
4. Install lining and coating prior to welding Threadolet or Half Coupling.
5. Provide Concrete Surround for pipe buried below structures.
6. Except at flanged connections at valves, flanged connections/joints not permitted on buried Ductile Iron Pipe.
7. FNPT tap at factory installed tapping boss. Taps at other locations on pipe and fittings are not permitted.
8. No lining or coating for Concrete Cylinder Pipe.
9. Bolts and nuts with metallurgy specified in AWWA C111.
10. BW (butt weld) connections/joints not permitted for 14-inch through 24 inch pipe.
11. Apply multiple wraps as necessary to achieve the specified system thickness.
12. Provide square nut operator, extension stem, and valve box for buried valves.

Schedule 40 05 02.29 - Plant Utility Water, Medium Pressure

Process Service	Plant Effluent Water				
Process Service Identifier	3W				

Indoor Dry, Indoor Wet, Outdoor, Process Corrosive, Headspace, Submerged - Exposed

Component	Line Size, in	Rating	Conn./Joints	Material	Spec Section	Notes
Pipe	1/8 thru 2-1/2	Sch. 40	THD	Steel: ASTM A53, Gr B, Type E or Type S, galvanized, Dim. Per ASME B36.10	40 05 24	
	3 thru 10	Sch. 40	CGRV, RGRV, FLG	Steel: ASTM A53, Gr B, Type E or Type S, Dim. Per ASME B36.10	40 05 24	
Lining for Pipe & Fittings	1/8 thru 2-1/2	—	—	None	—	
	3 thru 48	Thk. per Std.	—	Cement Mortar: Factory Applied, AWWA C205, NSF 61 certified	40 05 24	
		16 mils DFT	—	Liquid Epoxy: Factory Applied, AWWA C210, NSF 61 certified		
		12 mils CFT	—	Fusion-Bonded Epoxy: Factory Applied, AWWA C213, NSF 61 certified		
		Thk. per Std.	—	Polyurethane: Factory Applied, AWWA C222, NSF 61 certified		
External Coating	All	16 mils DFT	—	Liquid Epoxy: Factory Applied, AWWA C210	40 05 24	
		16 mils DFT	—	Three Coat Zinc/Epoxy/Urethane: Factory Applied, AWWA C218		
		Thk. per Std.	—	Polyurethane: Factory Applied, AWWA C222		
	Valves	16 mils DFT	—	Liquid Epoxy: Factory Applied, AWWA C210	40 05 24	
Fittings	1/8 thru 2-1/2	Class 300	THD	Malleable Iron: ASTM A47 or A197, galvanized, Dim. per ASME B16.3.	40 05 24	
		Class 300	THD	Ductile Iron: ASTM A536-Gr 65/45/12, galvanized, Dim. per ASME B16.3		
		Class 3000	THD	Forged Steel: ASTM A105, galvanized, Dim. per ASME B16.11		
	3 thru 24	Class 300	CGRV, RGRV	Malleable Iron Grooved End: ASTM A47, Dim. per manufacturer's standard	40 05 24	2
		M or E Pipe	CGRV, RGRV	Ductile Iron Grooved End: ASTM A536-Gr 65/45/12, Dim. per manufacturer's standard		
		Sch. 40 or Std. Wt.	CGRV, RGRV	Wrought Steel Grooved End: ASTM A234-WPB, r/D dim. per ASME B16.9, ASTM A53 grooved tangents per manufacturer's standard dim.		
		Sch. 40 or Std. Wt.	CGRV, RGRV	Fabricated Steel Grooved End: ASTM A53, Gr B, Type E or Type S, Dim. per manufacturer's standard		
		Sch. 40 or Std. Wt.	FLG	Wrought Steel: ASTM A234-WPB, Dim. per ASME B16.9		
		Sch. 40 or Std. Wt.	BW, FLG	Wrought Steel: ASTM A234-WPB, Dim. per ASME B16.9		2, 10

Schedule 40 05 02.29 - Plant Utility Water, Medium Pressure

Process Service	Plant Effluent Water				
Process Service Identifier	3W				

Indoor Dry, Indoor Wet, Outdoor, Process Corrosive, Headspace, Submerged - Exposed

Component	Line Size, in	Rating	Conn./Joints	Material	Spec Section	Notes
Taps	1/2 thru 2-1/2	Class 3000 Class 300 Class 300	THD THD THD	Forged Steel Tee: ASTM A105, galvanized, Dim. per ASME B16.11 Ductile Iron Tee: ASTM A536-Gr 65/45/12, galvanized, Dim. per ASME B16.3 Malleable Iron Tee: ASTM A47 or ASTM A197, galvanized, Dim. per ASME B16.3	40 05 24	
	3 thru 48	Class 3000	FP Beveled Fillet Weld	Forged Steel Threadolet or Half Coupling: ASTM A105, Dim. per ASME B16.11	40 05 24	4
Grooved Coupling	3 thru 24	M or E Pipe	CGRV, RGRV	Rigid Coupling: ASTM A536-Gr 65/45/12, Groove Dim. per AWWA C606 Flexible Coupling: ASTM A536-Gr 65/45/12, Groove Dim. per AWWA C606	40 05 24	
Flanges	4 thru 24	Class 300 Class E	LWN, WN, SO SO	Forged Steel: ASTM A105, FF, Dim. per ASME B16.5 Plate Steel: FF, Material and Dim. per AWWA C207	40 05 24	
FLG Bolts, nuts and hardware	All	All	—	Alloy Steel Bolts: ASTM A193-Gr B7 with Carbon Steel Nuts: ASTM A194-Gr 2H heavy hex	—	1
Flange gaskets	1/8 thru 10	1/16 in Thk.	FLG	Compressed organic fibers (Kevlar) with neoprene binder	40 05 01	
Mechanical Coupling Gaskets	3 thru 48	—	CGRV, RGRV	EPDM	40 05 01	
Compression and Push-On Gaskets	All	—	—	None	—	
Valves	1/4 thru 2-1/2		THD	Ball: Bronze Body/Ball, 40 05 63.02 Globe: Bronze, 40 05 66.01 Swing Check: Bronze 40 05 65.18	40 05 60	
	3 thru 48		FLG	Butterfly: AWWA C504, Class 250B, 40 05 64.06 Swing Check: Lever Arm and Spring, Class 250, 40 05 65.17	40 05 60	
Insulation	3/8 thru 8	1 in. Thk		Cellular Elastomeric: ASTM C534-Type I Grade 1, Low Temperature Range, Freeze Protection, PVC Jacket/Covers	40 42 00	

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Schedule 40 05 02.30 – Piping System Schedule, Plant Utility Water, High Pressure Hot Water

Process Service	High Pressure Hot Water				
Process Service Identifier	HPHW				

General Requirements

A. **Testing Requirements: Pressure: 2000 psig. Duration: 120 min Medium: Non-Potable Water**

B. Comply with the provisions of Section 40 05 01 in addition to the requirements specified herein. Refer to Section 40 05 02 for definitions of abbreviations and acronyms used in this schedule.

C. Design, fabricate, inspect, and test in accordance with the ASME B31.1 Process Piping Code.

D. **ASME B31.1 Design Requirements: Pressure: 2000 psig. Temperature: Ambient to 425 F Fluid Type: Non-Potable Water,**

E. Full-faced flanges mated with raised face flanges are not permitted.

F. Mating flanges shall be of the same Standard, Class, and Series.

G. Pipe threads per ASME B1.20.1.

H. Match metal alloy/grade/type for any metal welded to pipe or fittings. (Do not weld carbon steel to stainless steel. e.g., Weld Type 316L to Type 316L pipe material.)

Key Notes (Indexed to Key Notes in the Piping System Schedule)

1. Flange bolt length per ASME B16.5 plus three additional threads. Hex head bolt dimensions per ASME B18.2.1. Class 2A standard coarse series threads per ASME B1.1, standard coarse thread series. Hex nut dimensions per ASME B18.2.2 (Heavy Hex). Class 2B standard coarse series threads per ASME B1.1.
2. Provide butt-welded reducing outlet tees per fittings section and ASME B16.9. Use Weld-olets, Thread-o-lets or Socket-o-lets for reducing outlet sizes less than indicated in ASME B16.9.
3. Butt weld ends per ASME B16.9 and B16.25.
4. Provide ASTM A105, Class 3000, threaded half coupling at tee junction for instrument tap
5. Provide threaded adapters at valves.
6. Provide butt welded connections, except at valves. Provide flanged connections at valves.
7. Provide pre-formed pipe insulation with aluminum jackets over valves, fittings, and appurtenances. Insulation material, insulation thickness, and cover material to match pipe insulation. Provide fiberglass or mineral wool flexible blanket insulation with non-combustible fabric covers where pre-formed insulation and covers are not available for valves, fittings, and appurtenances. Flexible blanket insulation with non-combustible fabric covers per Section 40 42 00, ASTM C553-Type **III**, IV, VI or VII. Match pipe Insulation thickness for flexible blanket insulation with non-combustible fabric covers. Insulation Service Type: Energy Conservation.
8. Provide Sch 160 for threaded joints on pipe sizes less than 1-1/2 inch diameter.
9. Insultation for HPHW not required.

Schedule 40 05 02.30 – Piping System Schedule, Plant Utility Water, High Pressure Cleaning Water

Process Service	High Pressure Hot Water				
Process Service Identifier	HPHW				

Indoor Dry, Indoor Wet, Outdoor, Process Corrosive, Headspace, Submerged - Exposed

Component	Line Size, in	Rating	Conn./Joints	Material	Spec Section	Notes
Pipe	1/2 thru 2	Sch. 80	SW, THD	Steel: ASTM A106, Grade B, SML, Black, Dim Per ASME B36.10	40 05 24	6,8
	2-1/2 thru 12	—	—	None	—	
Lining for Pipe and Fittings	1/2 thru 12	—	—	None	—	
External Coating	1/2 thru 12	—	—	None	—	
	Valves	—	—	None	—	
Fittings	1/2 thru 2	Class 3000	SW	Forged Steel: ASTM A105, Dim per ASME B16.11	40 05 24	2, 6
	2-1/2 thru 12	—	—	None	—	
Taps	1/2 thru 2	Class 3000	SW x THD x SW	Forged Steel Reducing Tee: ASTM A105, Dim per ASME B16.11	40 05 24	3
		Class 3000	SW x SW x SW	Forged Steel Reducing Tee: ASTM A105, Dim per ASME B16.11	40 05 24	
	2-1/2 thru 12	—	—	None	—	
Flanges	2-1/2 thru 12	—	—	None	—	
Flange bolts, nuts and hardware	All	All	—	Alloy Steel Bolts: ASTM A193 - Gr B7 with Alloy Steel Nuts: ASTM A194 - Gr 2H	—	1
Flange gaskets	All	1/16 in Thk	FLG	Compressed gaskets consisting of Kevlar organic fibers and neoprene binder, suitable for design temperature.	40 05 01	
Valves	1/2 thru 2	—	THD	Ball: Stainless Steel, 40 05 63.03	40 05 60	6
	2-1/2 thru 12	—	—	None	—	
Insulation	1/2 thru 4	3 in. Thk.	—	Fiberglass or Mineral Wool: ASTM C547-Type I Grade A with Aluminum Jacket/Covers. Insulation Service Type: Energy Conservation.	40 42 00	8, 9
	5 thru 12	—	—	None	—	

END OF SECTION

Schedule 40 05 02.43 – Pressurized Wastewater and Drainage

Process Service	Plant Drain	F			
Process Service Identifier	PD	Filtrate			

Test Conditions

Pressure (psig)	Duration (min.)	Medium
200	120	Water

General Requirements

1. Full-Faced flanges mated with raised face flanges are not permitted.
2. Mating flanges for pipe shall be of the same Standard, Class and Series. Mating flanges at valves and equipment shall have specified rating and matching drilling pattern.
3. Pipe Threads per ASME B1.20.1.
4. Match metal alloy/grade/type for any metal welded to pipe or fittings. (e.g. Do not weld carbon steel to stainless steel; weld Type 316L to Type 316L pipe material.)
5. Solvent welding of PVC piping performed with Weld-On 724 (ASTM F 493, NSF/ANSI 14, NSF/ANSI 61) or Approved Equal. Universal plastic pipe solvent is not acceptable. Prior to solvent welding, clean pipe joints to remove all loose debris and prime with a compatible primer. Primer shall stain piping.

Notes:

1. Flange bolt length per ASME B16.5 plus three additional threads. Hex head bolt dimensions per ASME B18.2.1. Class 2A standard coarse series threads per ASME B1.1, standard coarse thread series. Hex nut dimensions per ASME B18.2.2 (Heavy Hex). Class 2B standard coarse series threads per ASME B1.1.
2. Provide Long Radius Elbows. Provide full flow fittings. Segmentally welded fittings are not acceptable.
3. Provide long radius five cut mitered elbows for segmentally welded fittings.
4. Install lining and coating prior to welding Threadolet or Half Coupling.
5. Provide Concrete Surround for pipe buried below structures.
6. Except at flanged connections at valves, flanged connections/joints not permitted on buried Ductile Iron Pipe.
7. FNPT tap at factory installed tapping boss. Taps at other locations on pipe and fittings are not permitted.
8. Bolts and nuts with metallurgy specified in AWWA C111.
9. BW (Butt Weld) and RJC (Ring Joint Coupling) connections/joints not permitted for 14-inch through 24 inch pipe.
10. Install plug valve with seat at the inlet or upstream connection to piping.
11. PGRV (Proprietary Groove): Victaulic Advanced Groove System or Approved Equal
12. RJC (Ring Joint Coupling): Victaulic Vic-Ring Coupling or Approved Equal with welded pipe shoulders or ring adapters
13. Where specified pipe wall thickness (Rating) is insufficient for cut grooves, provide shouldered ends, ring adapters, or increase pipe wall thickness as necessary for installation of cut grooves.
14. Rolled or cut grooves installed prior to application of glass lining. Field installation of grooves is not permitted.

Schedule 40 05 02.43 – Pressurized Wastewater and Drainage

Process Service	Plant Drain	F			
Process Service Identifier	PD	Filtrate			

Indoor Dry, Indoor Wet, Outdoor, Process Corrosive, Headspace, Submerged - Exposed

Component	Line Size, in	Rating	Conn./Joints	Material	Spec Section	Notes
Pipe	1/8 thru 2-1/2	Sch. 40	THD	Steel: ASTM A53, Gr B, Type E or Type S, galvanized, Dim. Per ASME B36.10	40 05 24	
	3 thru 12	Class 53	CGRV, RGRV, FLG	Ductile Iron: ASTM A536-Gr 65/45/12, galvanized, Dim. per ASME B16.3	40 05 19	
Lining for Pipe & Fittings	1/8 thru 2-1/2	—	—	None	—	
	3 thru 72	10 mils 12 mils CFT	— —	Glass: Ferrock MEH-32, Vitco SG-14 or equal Fusion-Bonded Epoxy: Factory Applied, AWWA C213, NSF 61 certified	40 05 19	
External Coating	All	16 mils DFT	—	Liquid Epoxy: Factory Applied, AWWA C210	40 05 19	
	Valves	16 mils DFT	—	Liquid Epoxy: Factory Applied, AWWA C210	40 05 19	
Fittings	1/8 thru 2-1/2	Class 150 Class 150 Class 3000	THD THD THD	Malleable Iron: ASTM A47 or A197, galvanized, Dim. per ASME B16.3 Ductile Iron: ASTM A536-Gr 65/45/12, galvanized, Dim. per ASME B16.3 Forged Steel: ASTM A105, galvanized, Dim. per ASME B16.11	40 05 24	
Fittings (continued)	3 thru 24	Class 150 M or E Pipe	CGRV CGRV	Malleable Iron Grooved End: ASTM A47, Dim. per manufacturer's standard Ductile Iron Grooved End: ASTM A536-Gr 65/45/12, Dim. per manufacturer's standard	40 05 24	14, 3 14, 3
Taps	1/2 thru 2-1/2	Class 3000 Class 150 Class 150	THD THD THD	Forged Steel Tee: ASTM A105, galvanized, Dim. per ASME B16.11 Ductile Iron Tee: ASTM A536-Gr 65/45/12, galvanized, Dim. per ASME B16.3 Malleable Iron Tee: ASTM A47 or ASTM A197, galvanized, Dim. per ASME B16.3	40 05 24	
	3 thru 72	Class 3000	FP Beveled Fillet Weld	Forged Steel Threadolet or Half Coupling: ASTM A105, Dim. per ASME B16.11	40 05 24	4

Schedule 40 05 02.43 – Pressurized Wastewater and Drainage

Process Service	Plant Drain	F			
Process Service Identifier	PD	Filtrate			

Indoor Dry, Indoor Wet, Outdoor, Process Corrosive, Headspace, Submerged - Exposed

Component	Line Size, in	Rating	Conn./Joints	Material	Spec Section	Notes
Grooved Coupling	3 thru 12	M or E Pipe	CGRV, RGRV	Rigid Coupling: ASTM A536-Gr 65/45/12, Groove Dim. per AWWA C606 Flexible Coupling: ASTM A536-Gr 65/45/12, Groove Dim. per AWWA C606	40 05 24	
	14 thru 24	M or E Pipe	CGRV, RGRV	Flexible Coupling: ASTM A536-Gr 65/45/12, Groove Dim. per AWWA C606	40 05 24	
	14 thru 72	M or E Pipe	PGRV, RJC	Flexible Coupling: ASTM A536-Gr 65/45/12, Groove Dim. per manufacturer's standard dim.	40 05 24	9
Flanges	4 thru 24	Class 150 Class D	LWN, WN, SO SO	Forged Steel: ASTM A105, FF, Dim. per ASME B16.5 Plate Steel: FF, Material and Dim. per AWWA C207	40 05 24	
	26 thru 72	Class D	SO	Plate Steel: FF, Material and Dim. per AWWA C207	40 05 24	
FLG Bolts, nuts and hardware	All	All	—	Alloy Steel Bolts: ASTM A193-Gr B7 with Carbon Steel Nuts: ASTM A194-Gr 2H heavy hex	—	1
Flange gaskets	1/8 thru 10	1/16 in Thk.	FLG	Nitrile or Neoprene	40 05 01	
	12 thru 72	1/8 in Thk.	FLG	Nitrile or Neoprene	40 05 01	
Mechanical Coupling Gaskets	3 thru 72	—	—	Nitrile or Neoprene	40 05 01	
Compression and Push-On Gaskets	All	—	—	None	—	
Valves	1/4 thru 2-1/2		THD	Ball: Bronze Body/Ball, 40 05 63.02	40 05 60	
				Swing Check: Bronze 40 05 65.01		
	3 thru 60		FLG	Plug: AWWA C517, Standard Port, 40 05 62.01	40 05 60	10
Insulation	All	—	—	None		

END OF SECTION

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Schedule 40 05 02.53 – Thickening and Dewatering

Process Service	Dewatered Biosolids	Digested Sludge	Screw Press Feed				
Process Service Identifier	DB	DS	SPF				

Test Conditions

Pressure (psig)	Duration (min.)	Medium
200	120	Water

General Requirements

1. Full-Faced flanges mated with raised face flanges are not permitted.
2. Mating flanges for pipe shall be of the same Standard, Class and Series. Mating flanges at valves and equipment shall have specified rating and matching drilling pattern.
3. Pipe Threads per ASME B1.20.1. Match metal alloy/grade/type for any metal welded to pipe or fittings. (e.g. Do not weld carbon steel to stainless steel; weld Type 316L to Type 316L pipe material.)
4. All welding and cutting must be performed before glass lining is applied. Field welding or field cutting glass lined pipe is not permitted.

Notes:

1. Bolt length per ASME B16.5 plus three additional threads. Hex head bolt dimensions per ASME B18.2.1. Class 2A standard coarse series threads per ASME B1.1, standard coarse thread series. Hex nut dimensions per ASME B18.2.2 (Heavy Hex). Class 2B standard coarse series threads per ASME B1.1.
2. Rolled or cut grooves installed prior to application of glass lining. Field installation of grooves is not permitted.
3. Provide Long Radius Elbows. Provide full flow fittings. Segmentally welded elbows are not acceptable.
4. Provide long radius five cut mitered elbows for segmentally welded fittings.
5. Provide square nut operator, extension stem, and valve box for buried valves.
6. Provide Concrete Surround for pipe buried below structures.
7. Bolts and nuts with metallurgy specified in AWWA C111.
8. Except at flanged connections at valves, flanged connections/joints not permitted on buried Ductile Iron Pipe.
9. FNPT tap at factory installed tapping boss.

Indoor Dry, Indoor Wet, Outdoor, Process Corrosive, Headspace, Submerged - Exposed

Component	Line Size, in	Rating	Conn./Joints	Material	Spec Section	Notes
Pipe	1/8 thru 2-1/2					
	3 thru 24	Class 53	CGRV, RGRV, FLG	Ductile Iron: ASTM A536-Gr 65/45/12, galvanized, Dim. per ASME B16.3	40 05 19	2
Lining for Pipe & Fittings	1/8 thru 2-1/2	—	—	None	—	
	3 thru 24	10 mils	—	Glass: Ferrock MEH-32, Vitco SG-14 or equal	40 05 24	

Schedule 40 05 02.53 – Thickening and Dewatering

Process Service	Dewatered Biosolids	Digested Sludge	Screw Press Feed				
Process Service Identifier	DB	DS	SPF				

Indoor Dry, Indoor Wet, Outdoor, Process Corrosive, Headspace, Submerged - Exposed

Component	Line Size, in	Rating	Conn./Joints	Material	Spec Section	Notes
External Coating	All	16 mils DFT	—	Liquid Epoxy: Factory Applied, AWWA C210	40 05 24	
	Valves	16 mils DFT	—	Manufacturer's Standard Shop Coating:	—	
Fittings	1/8 thru 2-1/2	Class 150	THD	Ductile Iron: ASTM A536-Gr 65/45/12, galvanized, Dim. per ASME B16.3	40 05 24	
	3 thru 24	Class 150	CGRV	Malleable Iron Grooved End: ASTM A47, Dim. per manufacturer's standard	40 05 24	2, 3
		M or E Pipe	CGRV	Ductile Iron Grooved End: ASTM A536-Gr 65/45/12, Dim. per manufacturer's standard		2, 3
Taps	1/2 thru 2-1/2	Class 3000	THD	Forged Steel Tee: ASTM A105, galvanized, Dim. per ASME B16.11	40 05 24	
		Class 150	THD	Ductile Iron Tee: ASTM A536-Gr 65/45/12, galvanized, Dim. per ASME B16.3		
		Class 150	THD	Malleable Iron Tee: ASTM A47 or ASTM A197, galvanized, Dim. per ASME B16.3		
	3 thru 72	Class 3000	FP Beveled Fillet Weld	Forged Steel Threadolet or Half Coupling: ASTM A105, Dim. per ASME B16.11	40 05 24	
Grooved Coupling	3 thru 12	M or E Pipe	CGRV, RGRV	Rigid Coupling: ASTM A536-Gr 65/45/12, Groove Dim. per AWWA C606 Flexible Coupling: ASTM A536-Gr 65/45/12, Groove Dim. per AWWA C606	40 05 24	
	14 thru 24	M or E Pipe	CGRV, RGRV	Flexible Coupling: ASTM A536-Gr 65/45/12, Groove Dim. per AWWA C606	40 05 24	
	14 thru 72	M or E Pipe	PGRV, RJC	Flexible Coupling: ASTM A536-Gr 65/45/12, Groove Dim. per manufacturer's standard dim.	40 05 24	10
Flanges	4 thru 24	Class 150	LWN, WN, SO	Forged Steel: ASTM A105, FF, Dim. per ASME B16.5	40 05 24	
		Class D	SO	Plate Steel: FF, Material and Dim. per AWWA C207		
	26 thru 72	Class D	SO	Plate Steel: FF, Material and Dim. per AWWA C207	40 05 24	
FLG Bolts, nuts and hardware	All	All	—	Carbon Steel Bolts: ASTM A307-Gr A. Carbon Steel Nuts: ASTM A563, 1/4" thru 1-1/2" use Gr A hex nuts, 1-5/8" thru 3" use Gr A heavy hex nuts.	—	1
Flange gaskets	1/8 thru 10	1/16 in Thk.	FLG	Nitrile or Neoprene	40 05 01	
	12 thru 72	1/8 in Thk.	FLG	Nitrile or Neoprene	40 05 01	
Mechanical Coupling Gaskets	3 thru 72	—	CGRV, RGRV	Nitrile: ASTM D2000 Type 5BG615A14B24 and AWWA C606 Neoprene	40 05 01	
Compression and Push-On Gaskets	All	—	—	None	—	

Schedule 40 05 02.53 – Thickening and Dewatering

Process Service	Dewatered Biosolids	Digested Sludge	Screw Press Feed				
Process Service Identifier	DB	DS	SPF				

Indoor Dry, Indoor Wet, Outdoor, Process Corrosive, Headspace, Submerged - Exposed

Component	Line Size, in	Rating	Conn./Joints	Material	Spec Section	Notes
Valves	3/4 thru 2-1/2	—	THD	Ball: Stainless Steel Ball/Body, 40 05 63.03	40 05 60	
	3 thru 48		FLG	Swing Check: Lever Arm and Spring, Class 150, 40 05 65.16Eccentric Plug: Standard Port, Glass Lined, 40 05 62.11		
Insulation	3/8 thru 8	1 in. Thk.	—	Cellular Elastomeric: ASTM C534-Type I Grade 1, Low Temperature Range, Freeze Protection, PVC Jacket/Covers	40 42 00	
	10 thru 72	1 in. Thk.	—	Cellular Elastomeric: ASTM C534-Type II Grade 1, Low Temperature Range, Freeze Protection, PVC Jacket/Covers	40 42 00	
	½ thru 36	1 in. Thk.	—	Fiberglass or Mineral Wool: ASTM C547-Type I Grade A, Medium-Temperature Range, Energy Conservation, Aluminum Jacket/Covers	40 42 00	19
	42 thru 60	1 in. Thk.	—	Fiberglass or Mineral Wool: ASTM C547-Type III Grade A, Medium-Temperature Range, Energy Conservation, Aluminum Jacket/Covers	40 42 00	19

END OF SECTION

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Schedule 40 05 02.63 – Chemical Solution (PVC)

Process Service	PO				
Process Service Identifier	Polymer Solution				

Test Conditions

Pressure (psig)	Duration (min.)	Medium
70	120	Water

General Requirements

1. Solvent welding of PVC piping performed with Weld-On 724 (ASTM F 493, NSF/ANSI 14, and NSF/ANSI 61) or Approved Equal. Universal plastic pipe solvent is not acceptable. Prior to solvent welding, clean pipe joints to remove all loose debris and prime with a compatible primer. Primer shall stain piping.
2. For SHS (VENT) provide pipe as for SHS
3. Full-Faced flanges mated with raised face flanges are not permitted.
4. Mating flanges for pipe shall be of the same Standard, Class and Series. Mating flanges at valves and equipment shall have specified rating and matching drilling pattern.
5. Pipe threads per ASME B1.20.1.

Notes:

1. Flange bolt length per ASME B16.5 plus three additional threads. Hex head bolt dimensions per ASME B18.2.1. Class 2A standard coarse series threads per ASME B1.1, standard coarse thread series. Hex nut dimensions per ASME B18.2.2 (Heavy Hex). Class 2B standard coarse series threads per ASME B1.1.
2. Apply Anti-seize to stainless steel bolts before turning nut on flange bolts.
3. Provide square nut operator, extension stem, and valve box for buried valves.
4. Install Secondary Containment on Exposed pipe and fittings to the limits specified on the Drawings. Secondary Containment Pipe per Section 40 05 31.19.
5. Install Secondary containment on all Buried and Encased pipe and fittings. Secondary Containment Pipe per Section 40 05 31.19.
6. Coat all pipe exposed to sunlight. Omit coating for insulated pipe.
7. For HOCL service, provide clear PVC vent lines on the discharge of automatic degassing valves.
8. Ball valves are not permitted on sodium hypochlorite service.

Indoor Dry, Indoor Wet, Outdoor, Submerged, Process Corrosive, Chemical Corrosive, Head Space – Exposed and Buried (Includes Encased and Embedded)

Component	Line Size, in	Rating	Conn./Joints	Material	Spec Section	Notes
Pipe	1/4 thru 24	Sch. 40	SLV	PVC: ASTM D1784-Class 12454-B, NSF 61 certified, Dim. Per ASTM D1785	40 05 31.13	4, 5
Lining for Pipe & Fittings	All	—	—	None	—	
External Coating	All	3 mils DFT	—	Latex Acrylic: Field Coated, Coating System L-2, Coat per Specification	09 90 00	6
	Valves	3 mils DFT	—	Latex Acrylic: Field Coated, Coating System L-2, Coat per Specification	09 90 00	6

Schedule 40 05 02.63 – Chemical Solution (PVC)

Process Service	PO				
Process Service Identifier	Polymer Solution				

Indoor Dry, Indoor Wet, Outdoor, Submerged, Process Corrosive, Chemical Corrosive, Head Space – Exposed and Buried (Includes Encased and Embedded)

Component	Line Size, in	Rating	Conn./Joints	Material	Spec Section	Notes
Fittings	All	Sch. 40	SLV	PVC: ASTM D1784-Class 12454-B, Dim. Per ASTM D2466	40 05 31.13	4, 5
Taps	All	Sch. 40	SLV	PVC Tee: ASTM A1784 Class 12454-B, Dim. Per ASTM D2466, Reducing bushings as necessary	40 05 31.13	
Grooved Coupling	None	—	—	None	—	
Flanges	None					
FLG Bolts, nuts and hardware	All	—	—	Stainless Steel Bolts: ASTM A320-B8M Stainless Steel Nuts: ASTM A194-8M Carbon Steel Bolts: ASTM A307-B with Xlyan fluoropolymer coating, Tripac 2000 Blue or approved equal Carbon Steel Nuts: ASTM A563-A with Xlyan fluoropolymer coating, Tripac 2000 Blue or approved equal	—	1, 2
Flange gaskets	None					
Mechanical Coupling Gaskets	None	—	—	None	—	
Compression and Push-On Gasket	None	—	—	None	—	
Valves	1/2		THD x SLV	PVC Degassing: 40 05 72.81	40 05 60	7
	1/8 thru 4	—	SLV	PVC Ball: 40 05 63.05 PVC Diaphragm:40 05 74.05 PVC Ball Check: 40 05 65.04	40 05 60	3, 8

END OF SECTION

Schedule 40 05 02.83 – Foul Air

Process Service	Foul Air					
Process Service Identifier	FA					

Test Conditions			Maximum Conditions	
Pressure (psig)	Duration (minutes)	Medium	Pressure (psi)	Temp. (degrees, F)
15	60	Air	-0.4 to 0.7	120

General Requirements

1. Line size based upon internal diameter. Provide pipe and or ductwork to ensure internal diameter meets or exceeds the specified line size.
2. Provide magnetic tracer tape for buried exposure.

Notes:

1. Install per ASTM 2321
2. Construct per SMACNA Round Industrial Duct Construction Standards.
3. Furnish flanged ends at transitions between pipe materials. Flange drilling pattern per ASME B16.5 Class 150 flange.
4. Bolt length per ASME B16.5 plus three additional threads. Hex head bolt dimensions per ASME B18.2.1. Class 2A standard coarse series threads per ASME B1.1. Hex nut dimensions per ASME B18.2.2 (Heavy Hex). Class 2B standard coarse series threads per ASME B1.1.
5. Apply anti-seize to bolt before turning.
6. Provide long radius elbows or five cut long radius mitered elbows.

Schedule 40 05 02.83 – Foul Air

Process Service	Foul Air					
Process Service Identifier	FA					

Indoor Dry, Indoor Wet, Outdoor, Process Corrosive

Component	Line Size, in	Rating	Conn./Joints	Material	Spec Section
Pipe	1 thru 6	Type 1	Bonded bell & spigot or FLG	Flexible PVC: ASTM D2241	—
	7 thru 36	Type 1	Bonded bell & spigot or FLG	Reinforced thermosetting resin (RTRP): ASTM D2310 and ASTM D2996 RTRP-12 EW1 or RTRP-11FW1 Type 4 resin	23 31 16
Fittings	1 thru 16	Class 150	Bonded bell & spigot or FLG	Reinforced thermosetting resin (RTRF): ASTM D5685, RTRF 52E4G.	—
Taps	All			None	--
Flanges	1 thru 16	Class 150	FLG	Reinforced thermosetting resin (RTR): ASTM D5421 CM-B4IF-46 or ASTM RTR-142E-EED	—
Flange bolts, nuts and hardware	All	All	—	Stainless Steel Bolts: ASTM A193, Gr B8 Stainless Steel Nuts: ASTM A194 Gr 8	—
Flange gaskets	1 thru 16		FLG	Gylon gasketing, Garlock Style 3504	—
Valves	4 thru 36	See Spec		Butterfly Damper: BD01	40 05 60

END OF SECTION

SECTION 40 05 06

SPECIALTY COUPLINGS AND ADAPTERS FOR PROCESS PIPING

PART 1 GENERAL

1.01 SUMMARY

A. Section includes specialty couplings and adapters to provide electrical isolation, connect misaligned pipe, provide pipeline flexibility, provide disconnection/dismantling capabilities, and other specialty functions in pipelines.

B. Connections, couplings, and joints used to connect pipe segments and fittings that are not specifically designed to provide the capabilities of a specialty coupling are specified with the pipe materials.

1.02 RELATED SECTIONS

A. This section contains specific references to the following related sections. Additional related sections may apply that are not specifically listed below.
   1. Section 01 61 45 – Area Exposure Designations
   2. Section 09 90 00 – Painting and Coating
   3. Section 40 05 01 – Piping Systems
   4. Section 40 05 02 – Piping System Schedules

1.03 REFERENCE STANDARDS

A. This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.

B. Unless otherwise specified, references to documents shall mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid (or on the effective date of the Agreement if there were no Bids). If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued. Where document dates are given in the following listing, references to those documents shall mean the specific document version associated with that date, regardless of whether the document

Reference	Title
ASME B31.1	Power Piping
ASME B31.9	Building Service Piping
ASME Section IX	Boiler and Pressure Vessel Code; Welding and Brazing Procedures, Welders, Brazers, and Welding and Brazing Operators Qualifications
ASTM A36	Standard Specification for Carbon Structural Steel
ASTM A53	Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless

Reference	Title
ASTM A193	Standard Specification for Alloy-Steel and Stainless Steel Bolting for High Temperature or High Pressure Service and Other Special Purpose Applications
ASTM A194	Standard Specification for Carbon and Alloy Steel Nuts for Bolts for High Pressure or High Temperature Service, or Both
ASTM A536	Standard Specification for Ductile Iron Castings
ASTM F593	Stainless Steel Bolts, Hex Cap Screws, and Studs
ASTM F594	Standard Specification for Stainless Steel Nuts
AWWA C105	Polyethylene Encasement for Ductile-Iron Pipe Systems
AWWA C111	Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings
AWWA C116	Protective Fusion-Bonded Epoxy Coatings for the Interior and Exterior Surfaces of Ductile-Iron and Gray-Iron Fittings
AWWA C153	Ductile-Iron Compact Fittings
AWWA C206	Field Welding of Steel Water Pipe
AWWA C213	Fusion-Bonded Epoxy Coating for the Interior and Exterior of Steel Water Pipelines
AWWA C219	Bolted, Sleeve-Type Couplings for Plain-End Pipe
AWWA C550	Protective Epoxy Coatings for Valves and Hydrants
AWWA C606	Grooved and Shouldered Joints
AWWA M11	AWWA M11 – Steel Pipe: A Guide for Design and Installation
NSF 61	Drinking Water System Components - Health Effects

1.04 SUBMITTALS

A. Action Submittals:
   1. Procedures: Section 01 33 00.
      a. A copy of this Section, addendum updates included, with each paragraph check-marked to indicate compliance or marked to indicate requested deviations.
      b. Manufacturers' product data, catalog cuts, typical installation details, and dimensions for each size and type of specialty coupling or adapter furnished for the project.

PART 2 PRODUCTS

2.01 GENERAL

A. Provide new specialty pipe couplings and adapters, free from defects and conforming to the requirements and standards specified in this Section.

B. Provide specialty couplings and adapters at locations indicated on drawings.

2.02 MECHANICAL COUPLINGS

A. Fasteners and Gaskets
   1. Except as otherwise specified in this Section, fasteners specified by Area Exposure Type. See Section 01 61 45 – Area Exposure Designations.
      a. Indoor Dry, Indoor Wet, and Outdoor: Manufacturer's Standard
      b. Process Corrosive, Headspace, Chemical Corrosive and Submerged: ASTM F593, Type 316 stainless steel, marking F593F.

c. Non-corrosive high-strength, Low-alloy steel, ASTM A449 Gr 3, Class C or Class D, with metallurgy specified in AWWA C111, regardless of any other protective coating.

2. Gasket material requirements for mechanical couplings are specified in the Piping System Schedules (Section 40 05 02.00 to Section 40 05 02.83).

B. Sleeve Couplings:

1. Candidate manufacturer:

a. Sleeve mechanical pipe couplings:

1) Xylem/Smith Blair Type 411.

2) Dresser Style 38.

3) Approved equal, with the stop removed from the middle ring.

b. Reducing Sleeve Couplings:

1) Xylem/Smith Blair Type 415.

2) Dresser Style 62.

3) Approved equal.

c. Sleeve Flanged Coupling Adapters:

1) Romac FCA 501.

2) Xylem/Smith Blair Type 913.

3) Dresser Style 128.

4) Approved equal.

d. Gaskets: Match gasket material specified for Mechanical Coupling Gaskets in the Piping System Schedule for the associated Process Service.

C. Equipment Connection Fittings:

1. Equipment connection fittings join flanged pipe ends with both lateral and angular misalignment adjustment between the axes of the pipes. In addition, equipment connection fittings provide full pressure thrust restraint between the field piping connection and equipment connection flanges.

a. Equipment connection fittings consist of two flanged coupling adapters, a plain end section of pipe and thrust restraint tie rods and associated fittings designed to transmit thrust without transmitting shear to the thrust restraint rods and without compromising provisions for accommodating angular and parallel misalignment.

b. Materials and features are to conform to the requirements established in this Section. Standard “dismantling joints” incorporate only one flanged coupling adapter and are not acceptable substitutes.

c. Candidate manufacturers:

1) Romac ECF Series

2) Baker Coupling Company, Los Angeles

3) Approved equal

2. Single sleeve of plain end piping conforming to the Piping System Schedule for the specified Process Service and of sufficient length to span the gap between the connection at the equipment and the connection at the field piping with Sleeve Flange Coupling Adapters at each end.

3. Provide thrust restraint by means of all-thread rod spanning between flanges. Rod nuts and spherical washer sets provide a ball-joint type self-aligning feature for all-thread thrust restraint rods. All-thread thrust restraint rods project through the flange and mating flange coupling adapter bolt holes or through holes in the restraint lug plates that extend beyond the flange diameter. Secure all-thread thrust restraint rod to the flanges with flange nuts or lug plates.
4. Provide lock washers between spherical washer sets and fastening nuts at both ends of all-thread thrust restraint rods. Double nutting with non-locking nuts is not an acceptable method of providing a self-locking feature.
5. All-thread thrust restraint rod diameter provides freedom of movement through all bolt holes to allow unrestricted maximum adjustment of equipment connection fittings to accommodate piping misalignment without transmitting any shear to the thrust rods and also to permit full development of thrust restraint at all thrust restraint rod tension take-ups.
6. Design equipment connection fittings per the requirements of AWWA C219.
7. Provide ASTM A193 grade B7, B8, or B8M thrust rods, ASTM A194 grade 2H, 8, or 8M nuts, with matching washers and lock washers to develop full rated piping system pressure thrust forces. For pump applications, select thrust rod quantities and diameters such that the thrust rod stretch under the piping system's operating pressure does not exceed 2.0 mils.
8. Factory apply dry film molybdenum disulfide anti-galling compound to ends of thrust rods, covering all threads subject to nut travel and tightening.
9. Gaskets:
    a. Flange gaskets: Match gasket material specified for Flange Gaskets in the Piping System Schedule for the associated Process Service.
    b. Follower gaskets: Compression Wedge. Match gasket material specified for Mechanical Coupling Gaskets in the Piping System Schedule for the associated Process Service.
10. Provide schedule 40, ASTM A53, Grade B pipe sleeves with ASTM A536, Grade 65-45-12 or ASTM A36 flange bodies and end rings. Pressure rating of flange adapters meet or exceed the pressure rating of the mating flanges. Coat and line all metal portions of equipment connection fittings, with the exception of 316 stainless steel components, with fusion bonded epoxy conforming to AWWA C550 and NSF 61.

D. Dismantling Joints:
1. Dismantling joints may be used as takedown couplings in accordance with this Specification.
    a. Dismantling joints: fully restrained double flange fittings consisting of a flange coupling adapter and flanged spool piece that allows for longitudinal adjustment.
    b. Provide thrust restraint by means of all threaded rod spanning between flanges and secured to the flanges with a minimum of two flange bolts.
    c. Design Dismantling Joints in accordance with AWWA C219.
    d. Provide schedule 40 ASTM A53 Grade B pipe sleeves with ASTM A536 Grade 65-45-12 or ASTM A36 flange bodies and end rings. The pressure ratings of the flange adapters are to meet or exceed the pressure rating of the mating flanges. Coat and line all metal portions of the fittings, with the exception of 316 stainless steel components, with fusion bonded epoxy conforming to AWWA C550 and NSF 61.

e. Candidate manufacturers:
    1) Romac DJ-400
    2) Smith Blair 975
    3) Crane-Viking Johnson Dismantling Joint
    4) Approved equal

E. Force Balanced Double Ball Expansion Joints
1. Install double ball expansion joints in the locations specified on the Drawings.
2. Provide foundry certification of material upon request. Materials as follows:
    a. Ductile iron joints conforming to the material requirements of ASTM A536 and AWWA C153.
    b. Type 410 stainless steel lock rings.
    c. EPDM molded watertight construction for ring gasket, casing, ball and cover.
3. Pressure test each expansion joint prior to shipment to a minimum of 250 PSI.
4. Flexible expansion joints consist of an expansion joint designed and cast as an integral part of a ball and socket type flexible joint, providing a minimum deflection of: 25 degrees per ball for 4-inch through 8-inch expansion joints; 20 degrees per ball for 10-inch and 12-inch expansion joints, and 15 degrees per ball for 14-inch and larger expansion joints. Two ball and socket joints are required for each Double Ball Expansion Joint.
5. Provide 10 inches minimum axial elongation capability with each single or double ball expansion joint. Furnish additional expansion sections as necessary to provide the specified minimum axial elongation capability.
6. Provide force balanced double ball expansion joint fittings that do not expand or exert an axial thrust under internal water pressure.
7. Line all metal surfaces, including the stainless steel lock rings, with a minimum of 15 mils of fusion bonded epoxy conforming to the applicable requirements of AWWA C213. Provide EPDM sealing gaskets. Provide NSF 61 compliant coatings and gaskets.
8. Coat exterior surfaces with a minimum of 6 mils of fusion bonded epoxy conforming to AWWA C116.
9. For buried installations, install polyethylene sleeve per AWWA C105, in accordance with the manufacturer's instructions.
10. Candidate manufacturers:
    a. Romac FJ Restraint
    b. Starflex Series 5000
    c. EBAA Iron, Flex-Tend
    d. Approved equal

2.03 UNIONS

A. 2-inch and Smaller: Ground joint screwed pattern unions.

B. 2 1/2-inch and Larger: Ground joint flange unions.

C. Dielectric Unions: Match the pipe material except bronze may be used with copper piping. Dielectric unions shall be EPCO, Capitol Manufacturing, or approved equal.

2.04 INSULATING FLANGES, COUPLINGS, AND UNIONS

A. Flange Insulating Kits: 2-1/2 inches and larger:
   1. Flanged, complete with bolt insulators, dielectric gasket, bolts, and nuts.
   2. In accordance with applicable piping material specified in Piping System Schedules (Section 40 05 02.00 through 40 05 02.83). Provide insulating flange assemblies per ASME B31.9 or B31.1. Flange assembly pressure/temperature rating equal to or greater than pipeline rating.
   3. Galvanically compatible with piping.
   4. Gaskets: Full-face, Type E, with elastomeric sealing element. Sealing element retained in a groove within retainer portion of gasket.
   5. Insulating Sleeves: Full-length fiberglass reinforced epoxy (NEMA G-10 grade).
   6. Insulating Washers: Fiberglass reinforced epoxy (NEMA G-10 grade).
   7. Steel Washers: Plated, hot-rolled steel, 1/8 inch thick.
   8. Manufacturers:
      a. Pipeline Seal and Insulator, Houston, TX
      b. Advance Products and Systems, Lafayette, LA
      c. Approved equal

B. Insulating Sleeve Couplings:
   1. Rockwell Type 416.
   2. Dresser Style 39.
   3. Approved equal.

C. Flexible Insulated Couplings:
   1. Dresser; STAB-39.
   2. Baker Coupling Company, Inc.; Series 216.
   3. Approved equal

D. Insulating Unions: Union Type, 2 inches and Smaller:
   1. Screwed or solder-joint.
   2. O-ring sealed with molded and bonded insulation to body.
   3. O-ring sealed with molded and bonded insulating bushing to union body, as manufactured by Central Plastics Co., Shawnee, OK.
   4. Approved equal

2.05 COATINGS

A. Field coat mechanical couplings in Buried exposure areas with System M-1 as specified in Section 09 90 00 – Painting and Coating.

PART 3 EXECUTION

3.01 FLEXIBILITY

A. Unless otherwise specified, pipe passing from concrete to earth shall be provided with two pipe couplings or flexible joints (or a double ball expansion joint) as specified on the Drawings. Locate pipe couplings within 24 inches of the structure for 2-inch through 6-inch diameter pipe; within 40 inches of the structure for 8-inch through 24-inch pipe; and within one and one-half pipe diameters of the structure for pipe larger than 24-inch. Where required for resistance to pressure, restrain mechanical couplings in accordance with Chapter 13 of AWWA M11, including Tables 13-4, 13-5 and 13-5A, and Figure 13-20.

B. Install Double Ball Expansion Joints with ¼ inch elongation/extension of the minimum axial elongation capability specified in this Section.

3.02 DIELECTRIC CONNECTIONS

A. Provide an insulating section of rubber or plastic pipe where a copper pipe is connected to steel or cast iron pipe. The insulating section shall have a minimum length of 12 pipe diameters.

B. Dielectric unions as specified in this Section may be used instead of the specified insulating sections.

END OF SECTION

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SECTION 40 05 06.33

PIPING APPURTENANCES

PART 1 GENERAL

1.01 SUMMARY

A. Scope of Section
   1. Review the process mechanical layout and the Process and Instrumentation Diagram(s) (P&ID) drawings within the Contract Documents that relate to the equipment specified in this Section to familiarize themselves with the location, arrangement and the application of the equipment specified and confirm that the equipment specified is appropriate for and coordinated with what is shown on the Drawings.
   2. This section specifies pipeline thermometers, flow and level gauges, pressure gauges, strainers, steam traps, vents and drains.

B. Exclusions:
   1. Temperature, pressure and flow measuring devices used for instrumentation are specified in Division 40.

C. Required Coordination
   1. Review the process mechanical layout and the Process and Instrumentation Diagram(s) (P&ID) drawings within the Contract Documents that relate to the equipment specified in this Section to familiarize themselves with the location, arrangement and the application of the equipment specified and confirm that the equipment specified is appropriate for and coordinated with what is shown on the Drawings.

1.02 RELATED SECTIONS

A. This Section contains specific references to the following related sections. Additional related Sections may apply that are not specifically listed below.
   1. Section 40 05 01 – Piping Systems
   2. Section 40 05 02 – Piping System Schedules
   3. Section 40 71 00 – Flow Measurement
   4. Section 40 73 00 – Pressure, Strain and Force Measurement

1.03 REFERENCE STANDARDS

A. This Section contains references to the following documents. Those documents are a part of this Section as specified and modified. In the event of conflict between the requirements of this Section and those of the listed documents, the requirements of this Section shall prevail.

B. Unless otherwise specified, references to documents shall mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid (or on the effective date of the Agreement if there were no Bids). If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued. Where document dates are given in the following listing, references to those documents shall mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, discontinued or replaced.

Reference	Title
SAMA PMC 17-10	Bushings and Wells for Temperature Sensing Elements

1.04 SUBMITTALS

A. The following minimum documentation shall be submitted per Section 01 33 00 - Submittal Procedures

B. Action Submittals: The following shall be submitted prior to construction of this element of the Work.

1. A copy of this specification section, with addendum updates included, and all referenced and applicable sections, with addendum updates included, with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements. Check-marks (✓) shall denote full compliance with a paragraph as a whole. Deviations shall be underlined and denoted by a number in the margin to the right of the identified paragraph. The remaining portions of the paragraph not underlined will signify compliance on the part of the Contractor with the specifications. Include a detailed, written justification for each deviation. Failure to include a copy of the marked-up specification sections, along with justification(s) for any requested deviations to the specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration.
2. Locate appurtenances on the piping layout drawings by plant area and submit in accordance with Section 40 05 01 – Piping Systems.
3. Maufacturer's product data.
4. Operations and Maintenance Manuals (including Warranty) in accordance with Section 01 78 23 – Operations and Maintenance Data

C. Closeout Submittals: The following minimum submittals shall be submitted for inspection.

1. Final Operations and Maintenance Manuals (including final Warranty documents) in accordance with Section 01 78 23 – Operations and Maintenance Data.

1.05 SHIPMENT AND STORAGE

A. Ship and store products in accordance with Section 01 66 00 – Product Storage and Handling.

B. Provide the Contractor with detailed recommendations and instructions for product storage.

PART 2 PRODUCTS

2.01 GENERAL

A. Unless otherwise specified or shown on the Drawings:
   1. All equipment shall be the same size as adjoining pipe.
   2. Body material of appurtenances shall match pipeline material.
   3. Pressure rating of appurtenances shall be no less than 150 psi.
   4. Electrical housings shall be NEMA 4X.

B. All units shall have the name of the manufacturer and the size of the unit cast on the body or shown on a permanently attached plate in raised letters.

C. All equipment provided shall be equipped with flanges, integral unions, or other functional connections for removal.

2.02 NOT USED

2.02 FLOW AND LEVEL GAUGES

A. Rotameters:
   1. Purge Rotameters (Seal Water):
      a. General:
         1) Variable area type
         2) Factory assembles with integral needle valve and flow controller.
         3) Range:
         4) 200 psi working pressure
      b. Flow control valve shall be pressure compensated to maintain set flow rate with constant upstream pressure and variable downstream pressure.
         1) Materials:
            a) Meter tube: glass
            b) Body and frame: 316 stainless steel
         2) 2) Acceptable manufacturers:
            a) Wallace and Tiernan: 32A113SSTX3.
            b) ITT Conoflow: GDH 2119 or GDH 2123
            c) Or Approved equal.
   2. NOT USED

B. Sight Guages:
   1. Type and material: automatic water guage complete with Pyrex guage glass and guage glass protector.
   2. Overall length of guages, type of mounting, and orientation of set shall be as specified.
   3. Acceptable manufacturers:
      a. 3/4-inch Penberthy.
      b. LDO Industries
      c. Or Approved equal.

C. Flow Indicators:
   1. Flow indicators shall be provided where specified.
   2. Fabrication: bronze body with threaded ends and a sight glass with rotary wheel.
   3. Pressure ratings for flow indicators shall match pipe pressure ratings.
   4. Acceptable manufacturers:
      a. Jacoby-Tarbox.
      b. Eugene Ernst Products.
      c. Or Approved equal.

2.03 PRESSURE DEVICES

A. Pressure guages for gas service other than air shall be per Section 40 73 00 – Pressure, Strain and Force Measurement.

B. Pressure Guages (water or air service only):
   1. Unless otherwise indicated, pressure guage scales shall be selected so that the normal operating pressure falls between 50 and 80 percent of full scale.
   2. Diameter: 4-1/2 inch.
   3. Movement: 270 degrees.
   4. Accuracy: 0.5 percent.
   5. Case: Non-metallic case with a 1/2-inch NPT bottom connection.
   6. Type: Premium grade, heavy duty Type 316 stainless steel bourdon tube units with plastic bushings and pinion, and stainless steel sector. Internal pulsation dampening system consisting of either a glycerin fill or a silicone fluid fill; snubbers or orifices are not acceptable.
   7. All gauges shall be vertically oriented.
   8. All gauges shall have an ½" isolation ball valve in accordance with Section 40 05 01 – Piping Systems.
   9. Bleed-off valves shall be ¼" ball valves in accordance with Section 40 05 01 – Piping Systems.
   10. Acceptable manufacturers:
      a. Ashcroft Duraguage 1279.
      b. Ametek 1981.
      c. Or Approved equal.

C. Diaphragm Seals:
   1. Type 1:
      a. Body and diaphragm material: Type 316 or Type 316L stainless steel.
      b. Flushing connection: 1/4-inch
      c. Process connection: 1/2-inch
      d. Unless otherwise indicated, fill fluid shall be Silicone DC200.
      e. Acceptable manufacturers:
         1) Ashcroft Type 101.
         2) Ametek.
         3) Or Approved equal.
   2. Type 2:
      a. Type: flexible sleeve type.
      b. Size: 1-inch, unless otherwise indicated.
      c. Unless otherwise indicated, sleeve shall be Buna-N.
      d. Acceptable manufacturers:
         1) Red Valve Series 742.
         2) Ashcroft Type 85
         3) Or Approved equal.

D. Flexible Sleeve Pressure Sensors:
   1. Type: in-line full stream captive sensing liquid type.
   2. Materials:
      a. wetted parts: 316 stainless steel
      b. sleeve: Buna-N, unless otherwise indicated
      c. capillary tubing: armored stainless steel
   3. Seals:
      a. Rated for 200 psi with 5-inch SC hysteresis.
      b. Acceptable manufacturer:
         1) Ronningen-Petter.
         2) Red Valve.
         3) Or Approved equal.
   4. Fill fluid shall be rated for a temperature range of -20 degrees F to 200 degrees F.
   5. Vacuum filling: Fittings shall be provided for vacuum filling of system. Systems that are not factory filled shall be vacuum filled in the field. Filling connections shall be soldered shut after vacuum evacuation and filling

2.04 STRAINERS (NOT USED)

2.05 QUICK CONNECT FITTINGS

A. Air and water utility station quick connect fittings.
   1. Acceptable manufacturers:
      a. Dixon Air King.
      b. Chicago Pneumatic.
      c. Or Approved equal.

B. All other quick connect fittings:
   1. Type: Coupler type, with cam arms. Capable of connecting to a hose adapter without the use of tools.
   2. Size: The same size as the pipeline.
   3. Materials: PVDF with Teflon gaskets.
   4. Acceptable manufacturers:
      a. Kamlock.
      b. Chicago Pneumatic.
      c. Or Approved equal.

2.06 IN LINE STATIC MIXER (NOT USED)

2.07 STEAM TRAPS (NOT USED)

PART 3 EXECUTION

3.01 GENERAL

A. Manufacturer to provide the Contractor with detailed recommendations and instructions for installation of the equipment specified in this Section.

3.02 PIPELINE THERMOMETERS (NOT USED)

3.03 GAGE TAPS

A. Provide guage taps on the suction and discharge of pumps, fans, compressors, vacuum pumps and blowers.

B. Guage taps for water and air service shall consist of a 1/4-inch guage cock attached by a threaded nipple to the pipeline, duct or equipment.

C. Guage taps and valves for gas service shall be in accordance with Section 40 73 00 – Pressure, Strain and Force Measurement.

3.04 VENTS AND DRAINS

A. Vents:
   1. Provide manual air vents at the high points of each reach of pipeline shown on the drawings, and provide additional manual drains as required and specified by the Project Representative after completion of piping installation.
   2. Provide manual air vents between all double block valves, as indicated on the drawings.

3. Air vents shall be 1-inch and shall consist of full port ball valve and copper tubing return.
4. Air vents shall be taken to the nearest floor with ball valve mounted 4 feet above the floor.
5. Fit vents in piping systems for fluids containing solids with quick couplers.

B. Drains:
1. Pipe each drain to a sump, gutter, floor drain or other collection point with a valve mounted 4 feet above the floor.
2. Drain valves in piping systems for fluids containing solids shall be threaded end full port plug valves of the size specified, fitted with quick couplers. All other drain valves shall be threaded end gate valves of the size specified, fitted with quick couplers.
3. When a drain cannot be run to a collection point, route the drain to a point of easy access and install a valve, of the type and size specified, fitted with a male threaded nipple suitable for connection to a hose.

3.05 FLEXIBLE SLEEVE PRESSURE SENSORS (NOT USED)

3.06 IN-LINE STATIC MIXER (NOT USED)

END OF SECTION

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SECTION 40 05 07

HANGERS AND SUPPORTS FOR PROCESS PIPING

PART 1 GENERAL

1.01 SUMMARY

A. This section specifies hangers and supports for all piping systems specified in Section 40 05 01. This section does not include pipe supports for fire sprinkler systems, pipe anchors, guides or seismic restraints.

1.02 REFERENCES

A. This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.

Reference	Title
AISC Manual of Steel Construction	American Institute of Steel Construction, Manual of Steel Construction, Allowable Stress Design - 9th Ed.
FEDSPEC WW-H-171e-78	Hangers and Supports, Pipe
MFMA-2-91	Metal Framing Standards Publication
MSS SP-69-91	Pipe Hangers and Supports - Selection and Application
MSS SP-58-93	Pipe Hangers and Supports - Materials, Design and Manufacture

1.03 SUBMITTALS

A. Action Submittals:
   1. Procedures: Section 01 33 00.
   2. A copy of this specification section with addenda updates, and all referenced sections with each paragraph check marked to show specification compliance or marked to show deviations.
   3. Identify hanger and support locations and components indicated on piping layout drawings as specified in Section 40 05 01.

1.4 QUALITY ASSURANCE

A. Refer to Section 40 05 01 for additional quality assurance requirements.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Procedures: Section 01 66 00.

B. Additional requirements: 40 05 01.

PART 2 PRODUCTS

2.01 PERFORMANCE/ DESIGN CRITERIA

A. Operating Conditions:
   1. The hangers and supports specified in this section are provided to resist pipe loads occurring primarily in the downward (gravity) direction. For the purpose of pipe hanger and support selection, this section establishes pipe support classifications based on the operating temperatures of the piping contents. Pipe support classifications are as follows:
      a. Hot Systems
         1) A - 1. 120 degrees F to 450 degrees F
         2) A - 2. 451 degrees F to 750 degrees F
         3) A - 3. Over 750 degrees F
      b. Ambient Systems
         1) B. 60 degrees F to 119 degrees F
      c. Cold Systems
         1) C - 1. 33 degrees F to 59 degrees F
         2) C - 2. -20 degrees F to 32 degrees F

B. Hanger and Support Selection:
   1. The Contractor shall select pipe hangers and supports as specified in the project manual. Selections shall be based upon the pipe support classifications specified in this section, the piping insulation thickness specified in Section 40 42 00, and any special requirements which may be specified in the project manual.
   2. The Contractor shall review the piping layout in relation to the surrounding structure and adjacent piping and equipment before selecting the type of support to be used at each hanger point.
   3. Hangers and supports shall withstand all static and specified dynamic conditions of loading to which the piping and associated equipment may be subjected. As a minimum, consideration shall be given to the following conditions:
      a. Weights of pipe, valves, fittings, insulating materials, suspended hanger components, and normal fluid contents.
      b. Weight of hydrostatic test fluid or cleaning fluid if normal operating fluid contents are lighter.
      c. Reaction forces due to the operation of safety or relief valves.
      d. Wind, snow or ice loadings on outdoor piping.
   4. Hangers and supports shall be sized to fit the outside diameter of pipe, tubing, or, where specified, the outside diameter of insulation.
   5. Where negligible movement occurs at hanger locations, rod hangers shall be used for suspended lines, wherever practical. For piping supported from below, bases, brackets or structural cross members shall be used.
   6. Hangers for the suspension of size 2 1/2 inches and larger pipe and tubing shall be capable of vertical hanger component adjustment under load.
   7. The supporting systems shall provide for and control the free or intended movement of the piping including its movement in relation to that of connected equipment.

8. Where there is horizontal movement at a suspended type hanger location, hanger components shall be selected to allow for swing. The vertical angle of the hanger rod shall not, at any time, exceed 4 degrees.
9. There shall be no contact between a pipe and hanger or support component of dissimilar metals. Prevent contact between dissimilar metals when supporting copper tubing by use of copper-plated, rubber, plastic or vinyl coated, or stainless steel hanger and support components.
10. Unless otherwise specified, existing pipes and supports shall not be used to support new piping.
11. Unless otherwise specified, pipe support components shall not be attached to pressure vessels.
12. Stock hanger and support components shall be used wherever practical.

2.02 MATERIALS

A. Standard pipe supports and components shall be manufactured by B-Line, Carpenter & Patterson, Kin-Line, Grinnell, Michigan, Pipe Shields Incorporated, Superstrut, Unistrut, or equal. Pipe support components shall conform to the requirements of MSS SP-69 and FEDSPEC WW-H-171e. Pipe support materials shall conform to the requirements of MSS SP-58. Metal framing system components shall conform to the metal framing manufacturers' Association Standard MFMA-2.

2.03 CONFIGURATION, COMPONENTS, FEATURES

A. General:
   1. Unless otherwise specified, pipe hangers and supports, structural attachments, fittings and accessories shall be hot-dip or mechanically galvanized after fabrication. Nuts, bolts and washers may be zinc-plated except for those subject to moisture or corrosive atmosphere, as specified in Section 01 61 45 Area Exposure Designations, which shall be Type 304 stainless steel. Also listed in Section 26 05 00-1.05 Hazardous (Classified) Areas are corrosive areas specifically requiring fiberglass materials. In those areas, all pipe support, anchor and brace components (not just fittings and accessories) shall be made of fiberglass.

B. Pipe Hangers and Supports:
   1. Type 1 - Clevis Pipe Hanger: Clevis hangers shall be carbon steel with configuration and components equivalent to MSS and FEDSPEC Type 1.
      a. Steel pipe (insulated) - shall be B-Line B3100, Grinnell Fig. 260, or equal, with insulation shield.
      b. Steel pipe (uninsulated) - shall be B-Line B3100, Grinnell Fig. 260, or equal.
      c. Cast and ductile iron pipe - shall be B-Line B3102, Grinnell Fig. 590, or equal.
      d. Copper pipe (uninsulated) - shall be B-Line B3104 CT, Grinnell Fig. CT-65, or equal.
      e. Copper pipe (insulated) - shall be B-Line B3100, Grinnell Fig. 260, or equal, with insulation shield.
      f. Plastic pipe - shall be B-Line B3100 C, Carpenter & Patterson Fig. 100PVC, or equal.

2. Type 2 - "J" Pipe Hanger: Hangers shall be carbon steel with configuration and components equivalent to MSS Type 5.
    a. Steel pipe - shall be B-Line B3690, Grinnell Fig. 67, Michigan model 418, or equal.
    b. Copper and plastic pipe - shall be Michigan model 419, Unistrut J 1205N series, or equal.
3. Type 6 - Framing Channel Pipe Clamp: Pipe clamps shall be steel with galvanized finish and material thickness as listed below:
    a. Steel pipe (uninsulated) - Pipe size 3/8 inch and 1/2 inch shall be 16 gage; 3/4 inch through 1 1/4 inches shall be 14 gage; 1 1/2 inches through 3 inches shall be 12 gage; 3 1/2 inches through 5 inches shall be 11 gage; 6 and 8 inches shall be 10 gage; Michigan model 431, Powerstrut PS 1100, Unistrut P 1109 series, or equal.
    b. Steel pipe (insulated) - Pipe clamp shall be as described in paragraph 2.03 Steel Pipe (Uninsulated) with insulation shield.
    c. Copper (uninsulated) and plastic pipe - Pipe size 3/8 inch and 1 inch shall be 16 gage; 1-1/4 inches and 1-1/2 inches shall be 14 gage; 2 inches through 3 inches shall be 12 gage; 4 inches shall be 11 gage; clamp shall be copper-plated, plastic coated or lined with dielectric material; Michigan model 432, Powerstrut PS 1200, Unistrut P 2024C and P 2024PC series, or equal.
    d. Copper pipe (insulated) - Pipe clamp shall be as described in paragraph 2.03 Steel Pipe (Uninsulated) with insulation shield.
4. Type 7 - U-BOLT: U-bolts shall be carbon steel with configuration equivalent to MSS and FEDSPEC Type 24.
    a. Steel pipe (uninsulated) - shall be Grinnell Fig. 137, B-Line B3188, or equal.
    b. Steel pipe (insulated) - shall be Grinnell Fig. 137, B-Line B3188, or equal, with insulation shield.
    c. Cast and ductile iron pipe - shall be Grinnell Fig. 137, B-Line B3188, or equal.
    d. Copper pipe (uninsulated) - shall be Carpenter & Patterson Fig. 222 CT, B-Line B3501 CT, Grinnell Fig. 137C, or equal.
    e. Copper pipe (insulated) - shall be Grinnell Fig. 137, B-Line B3188, or equal, with insulation shield.
    f. Plastic pipe - shall be Grinnell Fig. 137C, Michigan model 151, B-Line B3188 C, or equal.
5. Type 9 - Welded Pipe Stanchion: Minimum material thickness shall be standard schedule carbon steel pipe, cut to match contour of the pipe elbow. Use of this support shall be limited to ambient systems only.
6. Type 10 - Pipe Stanchion Saddle: Saddles and yokes shall be carbon steel and comply with MSS Type 37 and FEDSPEC Type 38.
    a. Steel pipe (insulated) - shall be Carpenter & Patterson Fig. 125, B-Line B3090, or equal, with insulation shield.
    b. Steel pipe (uninsulated) - shall be Carpenter & Patterson Fig. 125, B-Line B3090, or equal.
    c. Cast and ductile iron pipe - shall be Carpenter & Patterson Fig. 125, B-Line B3090 NS, or equal.
    d. Copper pipe (uninsulated) - shall be Carpenter & Patterson Fig. 125, B-Line B3090, or equal, with insulation shield or lined with dielectric material.

e. Copper pipe (insulated) - shall be Carpenter & Patterson Fig. 125, B-Line B3090, or equal, with insulation shield.

f. Plastic pipe - shall be Carpenter & Patterson Fig. 125, B-Line B3090, or equal.

7. Type 12 - Riser Clamp: Riser clamp shall be carbon steel with configuration and components equivalent to MSS and FEDSPEC Type 8.

a. Steel pipe (insulated) - shall be B-Line B3373, Grinnell Fig. 261, or equal.

b. Steel pipe (uninsulated) - shall be B-Line B3373, Grinnell Fig. 261, or equal.

c. Cast and ductile iron pipe - shall be B-Line B3373, Grinnell Fig. 261, or equal.

d. Copper pipe (insulated) - shall be B-Line B3373 CT, Grinnell Fig. CT-121, Michigan model 511, or equal.

e. Copper pipe (uninsulated) - shall be B-Line B3373 CT, Grinnell Fig. CT-121, Michigan model 511, or equal.

f. Plastic pipe - shall be B-Line B3373, Grinnell Fig. 261c, or equal.

8. Type 13 - Framing Channel Pipe Strap: Pipe strap shall be carbon steel, with configuration equivalent to MSS Type 26.

a. Steel pipe (uninsulated) - shall be Superstrut No. C-708-U, Powerstrut PS 3126, Kin-Line No. 477, or equal.

b. Steel pipe (insulated) - shall be Superstrut No. C-708-U, Powerstrut PS 3126, Kin-Line No. 477, or equal, with insulation shield.

c. Copper pipe (uninsulated) - shall be Superstrut No. C-708-U, Powerstrut PS 3126, Kin-Line No. 477, or equal, with insulation shield or lined with dielectric material.

d. Copper pipe (insulated) - shall be Superstrut No. C-708-U, Powerstrut PS 3126, Kin-Line No. 477, or equal, with insulation shield.

e. Plastic pipe - shall be Superstrut No. C-708-U, Powerstrut PS 3126, Kin-Line No. 477, or equal.

C. Rack and Trapeze Supports:

1. General: Unless otherwise specified, trapeze and pipe rack components shall have a minimum steel thickness of 12 gage, with a maximum deflection 1/240 of the span.

2. Type 20 - Trapeze Pipe Support: Trapeze pipe support cross members shall be framing channel as specified in paragraph 2.03 Framing Channel. Flat plate fittings shall be 1 5/8-inch square carbon steel of standard design manufactured by framing channel manufacturer, Unistrut P2471, B-Line B202-2, or equal.

D. Structural Attachments:

1. Type B - Side Beam Bracket: Bracket shall be malleable iron and comply with MSS Type 34 and FEDSPEC Type 35. Grinnell Fig. 202, B-Line B3062, or equal.

2. Type C - Malleable Beam Clamp With Extension Piece: Clamp and extension piece shall be malleable iron, tie rod shall be steel. Beam clamp shall comply with MSS and FEDSPEC Type 30. Grinnell Fig. 218 with Fig. 157 extension piece, B-Line B3054, or equal.

3. Type D - Steel Beam Clamp With Eye Nut: Beam clamp and eye nut shall be forged steel. Configuration and components shall comply with MSS and FEDSPEC Type 28. Grinnell Fig. 292, Carpenter & Patterson Fig. 297, or equal.

4. Type G - Welded Steel Bracket: Bracket shall be carbon steel and comply with MSS Type 32 and FEDSPEC Type 33 for medium welded bracket. Heavy welded bracket shall comply with MSS Type 33 and FEDSPEC Type 34.

5. Type K - Double Channel Bracket: Wall channel shall be single channel framing channel as specified in paragraph 2.03 Framing Channel. Cantilever bracket shall be a carbon steel double framing channel assembly, Unistrut P2542 through P2546, B-Line B297-12 through B297-36, or equal.
6. Type L - Single Channel Bracket: Wall channel shall be single channel framing channel as specified in paragraph 2.03 Framing Channel. Cantilever bracket shall be a carbon steel single framing channel assembly, Unistrut P2231 through P2234, B-Line B198-6, B198-12, B196-18 and B196-24, or equal.
7. Type M - Wall Mounted Channel: Wall channel shall be single channel framing channel as specified in paragraph 2.03 Framing Channel.
8. Type N - Pipe Stanchion Floor Attachment: Baseplate shall be carbon steel with 1/2 inch minimum thickness. Anchor bolt holes shall be 1/16 inch larger than the anchor bolt diameter. The space between the baseplate and the floor shall be filled with nonshrink grout.

E. Accessories:
1. Hanger Rods: Rods shall be carbon steel, threaded on both ends or continuous threaded and sized as specified.
2. Weldless Eye Nut: Eye nut shall be forged steel and shall comply with MSS and FEDSPEC Type 17. Eye nut shall be Grinnell Fig. 290, B-Line B3200, or equal.
3. Welded Eye Rod: Eye rod shall be carbon steel with eye welded closed. Inside diameter of eye shall accommodate a bolt diameter 1/8 inch larger than the rod diameter. Eye rod shall be Grinnell Fig. 278, B-Line B3211, or equal.
4. Turnbuckle: Turnbuckle shall be forged steel and shall comply with MSS and FEDSPEC Type 13. Turnbuckle shall be Grinnell Fig. 230, B-Line B3202, or equal.
5. Framing Channel: Framing channel shall be 1 5/8 inches square, roll formed, 12-gage carbon steel. Channel shall have a continuous slot along one side with in-turned clamping ridges. Single channel: Unistrut P1000, B-Line B22, or equal. Double channel: Unistrut P1001, B-Line B22A, or equal. Triple channel: Unistrut P1004A, B-Line B22X, or equal.

2.04 THERMAL PIPE HANGER SHIELD

A. Thermal shields shall be provided at hanger, support and guide locations on pipe requiring insulation. The shield shall consist of an insulation layer encircling the entire circumference of the pipe and a steel jacket encircling the insulation layer. The thermal shield shall be the same thickness as the piping system insulation specified in Section 40 42 00. The standard shield shall be used for hot systems and the vapor barrier shield shall be used for cold systems. Stainless steel band clamps shall be used where specified to ensure against slippage between the pipe wall and the thermal shield.

B. Standard Shield:
1. Insulation:
a. Hydrous calcium silicate, high density, waterproof
b. Compressive strength: 100 psi average
c. Flexural strength: 75 psi average
d. K factor: 0.38 at 100 degrees F mean
e. Temperature range: 20 degrees F to 500 degrees F

2. Steel Jacket: Galvanized steel. Gage shall be the manufacturer's standard supplied for the given pipe size.
3. Connection: Shield shall have butt connection to pipe insulation. Steel jacket and insulation shall be flush with end.

C. Vapor Barrier Shield:
1. Insulation:
a. Hydrous calcium silicate, high density, waterproof
b. Compressive strength: 100 psi average
c. Flexural strength: 75 psi average
d. K factor: 0.38 at 100 degrees F mean
e. Temperature range: 20 degrees F to 500 degrees F
2. Steel Jacket: Galvanized steel. Gage shall be the manufacturer's standard supplied for the given pipe size.
3. Connection: Shield shall have butt connection to pipe insulation. Insulation shall extend 1 inch each side of steel jacket for vapor tight connection to pipe insulation vapor barrier.

PART 3 EXECUTION

3.01 HANGER AND SUPPORT LOCATIONS

A. The Contractor shall locate hangers and supports as near as possible to concentrated loads such as valves, flanges, etc. Locate hangers, supports and accessories within the maximum span lengths specified in the project manual to support continuous pipeline runs unaffected by concentrated loads.

B. At least one hanger or support shall be located within 2 feet from a pipe change in direction.

C. The Contractor shall locate hangers and supports to ensure that connections to equipment, tanks, etc., are substantially free from loads transmitted by the piping.

D. Where piping is connected to equipment, a valve, piping assembly, etc., that will require removal for maintenance, the piping shall be supported in such a manner that temporary supports shall not be necessary for this procedure.

E. Pipe shall not have pockets formed in the span due to sagging of the pipe between supports caused by the weight of the pipe, medium in the pipe, insulation, valves and fittings.

3.02 INSTALLATION

A. Welded and bolted attachments to the building structural steel shall be in accordance with the requirements of the AISC Manual of Steel Construction. Unless otherwise specified, there shall be no drilling or burning of holes in the building structural steel.

B. Hanger components shall not be used for purposes other than for which they were designed. They shall not be used for rigging and erection purposes.

C. The Contractor shall install items to be embedded before concrete is poured. Fasten embedded items securely to prevent movement when concrete is poured.

D. Embedded anchor bolts shall be used instead of concrete inserts for support installations in areas below water surface or normally subject to submerging.

E. The Contractor shall install thermal pipe hanger shields on insulated piping at required locations during hanger and support installation. Butt joint connections to pipe insulation shall be made at the time of insulation installation in accordance with the manufacturer's recommendations.

F. Hanger and support components in contact with plastic pipe shall be free of burrs and sharp edges.

G. Rollers shall roll freely without binding.

H. Finished floor beneath Type N structural attachments and framing channel post bases shall be roughed prior to grouting. Grout between base plate and floor shall be free of voids and foreign material.

I. Baseplates shall be cut and drilled to specified dimensions prior to welding stanchions or other attachments and prior to setting anchor bolts.

J. Plastic or rubber end caps shall be provided at the exposed ends of all framing channels that are located up to 7 feet above the floor.

3.03 ADJUSTMENTS

A. The Contractor shall adjust hangers and supports to obtain required pipe slope and elevation. Shims made of material that is compatible with the piping material may be used. Stanchions shall be adjusted prior to grouting their baseplates.

3.04 ANCHOR BOLTS

A. Anchor bolts in new concrete shall be cast in place. Refer to Section 05 05 20.

END OF SECTION

SECTION 40 05 07.13

SEISMIC RESTRAINTS FOR PIPING

PART 1 GENERAL

1.01 SUMMARY

A. This section specifies seismic restraints for bracing all piping systems specified in Section 40 05 01. This section does not include seismic restraints for fire sprinkler systems.

1.02 REFERENCES

A. This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section prevail.

Reference	Title
ANSI A58.1-82	Minimum Design Loads for Buildings and Other Structures
AISC Manual of Steel Construction	American Institute of Steel Construction, Manual of Steel Construction, Allowable Stress Design - 9th Edition
FEDSPEC WW-H-171e-78	Hangers and Supports, Pipe
MFMA-2-91	Metal Framing Standards Publication
MSS SP-58-93	Pipe Hangers and Supports - Materials, Design and Manufacture
MSS SP-69-91	Pipe Hangers and Supports - Selection and Application
SMACNA, PPIC	Guidelines for Seismic Restraints of Mechanical Systems and Plumbing Piping Systems

1.03 DEFINITIONS

A. Terminology used in this Section conforms to the following definitions:
   1. Longitudinal direction: direction parallel to the pipe axis.
   2. Lateral direction: direction perpendicular to the pipe axis.

1.04 ADMISTRATIVE REQUIREMENTS

A. Cordination:
   1. Coordination required with the design of piping systems, pipe supports, and expansion control and seismic restraints.
   2. Refer to Section 40 05 01 for additional coordination requirements.

1.05 SUBMITTALS

A. Informational Submittals:
   1. Procedures: Section 01 33 00.

2. Seismic restraint locations and legend as specified in paragraph 3.01.
3. Seismic restraint load calculations as specified in paragraph 1.06 Quality Assurance.

1.06 QUALITY ASSURANCE

A. Refer to Section 40 05 01 for additional quality assurance requirements.

B. Seismic restraint load calculations specified in paragraph 3.01 shall be reviewed and signed by a structural engineer registered in the State of Washington.

1.07 DELIVERY, STORAGE, AND HANDLING

A. Procedures: Section 01 66 00.

B. Additional requirements: 40 05 01.

PART 2 PRODUCTS

2.01 PERFORMANCE/ DESIGN REQUIREMENTS

A. Service Conditions:
   1. The seismic restraints specified in this section are provided to resist pipe movements and loads occurring as a result of an earthquake or other seismic event.
   2. Unless otherwise specified, all piping shall have bracing to resist seismic loading caused by forces applied at the individual pipe's center of gravity. Seismic loading shall be 0.375 g acting in the lateral and longitudinal directions and 0.17 g acting simultaneously in the vertical directions.

B. Restraint Selection:
   1. Unless otherwise specified, the Contractor shall select, locate and provide seismic restraints for piping in accordance with the project manual.
   2. The Contractor shall review the piping layout in relation to the surrounding structure and adjacent piping and equipment before selecting the restraint to be used at each point.
   3. Seismic restraints may be omitted from the following installations:
      a. Gas piping less than 1-inch inside diameter.
      b. Piping in boiler and mechanical rooms less than 1 1/4-inch inside diameter.
      c. All other piping less than 2 1/2-inch inside diameter.
      d. All piping suspended by individual hangers 12 inches or less in length from the top of the pipe to the bottom of the support for the hanger.
   4. Piping systems shall not be braced to dissimilar parts of a building or to dissimilar building systems that may respond in a different mode during an earthquake. Examples: wall and a roof; solid concrete wall and a metal deck with lightweight concrete fill.
   5. Restraints shall be sized to fit the outside diameter of the pipe, tubing, or, where specified, the outside diameter of insulation.

6. There shall be no contact between a pipe and restraint component of dissimilar metals. The contractor shall prevent contact between dissimilar metals when restraining copper tubing by the use of copper-plated, rubber, plastic or vinyl coated, or stainless steel restraint components.
7. Branch lines shall not be used to brace main lines.
8. Seismic bracing shall not limit the expansion and contraction of the piping system.

2.02 MANUFACTURERS

A. Standard pipe restraints and components shall be manufactured by Carpenter & Patterson, B-Line, Kin-Line, ITT Grinnell, Michigan, Pipe Shields Incorporated, Superstrut, Unistrut, or equal. Pipe restraint materials shall conform to the requirements of MSS SP-58 and MFMA-1.

2.03 MATERIALS

A. General:
   1. Unless otherwise specified, restraints, including braces, pipe and structural attachments, shall be hot-dip galvanized after fabrication. Nuts, bolts and washers, fittings and accessories, may be mechanically zinc-coated except for those subject to moisture or corrosive atmosphere, which shall be type 304 stainless steel.

B. Pipe Attachments:
   1. Type 1s: Clevis Restraint Attachment: Clevis attachment shall be Type 1, clevis pipe hanger, as specified in Section 40 05 07-2.03 Pipe Hangers and Supports.
   2. Type 7s: U-Bolt Restraint: U-bolt restraint shall be Type 7, U-bolt, as specified in Section 40 05 07-2.03 Pipe Hangers and Supports.
   3. Type 13s: Framing Channel Strap Restraint: Strap restraint shall be Type 13, framing channel pipe strap, as specified in Section 40 05 07-2.03 Pipe Hangers and Supports.
   4. Type 14s: Pipe Clamp Restraint: Pipe clamp shall be carbon steel, with configuration and components equivalent to MSS and FEDSPEC Type 4. Rod attachment and longitudinal brace connection stud shall be carbon steel, fabricated and welded by the manufacturer.
      a. Steel pipe (insulated)–shall be Superstrut No. S-720, Kin-Line No. S475, or equal, with insulation shield.
      b. Steel pipe (uninsulated)--shall be Superstrut No. S-720, Kin-Line No. S475, or equal.
      c. Cast and ductile iron pipe–shall be Superstrut No. S-720, Kin-Line No. S475, or equal.
      d. Copper pipe (insulated)–shall be Superstrut No. S-720, Kin-Line No. S475, or equal, with insulation shield.
      e. Copper pipe (uninsulated)–shall be Superstrut No. S-720, Kin-Line No. S475, or equal, with insulation shield or dielectric lining.
      f. Plastic pipe--shall be Superstrut No. S-720, Kin-Line No. S475, or equal.

C. Trapeze Restraints:

1. General: Unless otherwise specified, trapeze members shall have a minimum steel thickness of 12 gage, with a maximum deflection 1/240 of the span.
2. Type 20s: Single Channel Lateral Restraint: Trapeze restraint cross member shall be 1 5/8-inch square carbon steel framing channel, Unistrut P1000, B-Line B22, Superstrut A-1200, or equal. Pipe attachments shall be Type 13s or Type 7s specified in paragraph 2.03 Pipe Attachments. Rod stiffeners and lateral brace shall be as specified in paragraph 2.03 Braces and Fittings.
3. Type 21s: Double Channel Lateral Restraint: Trapeze restraint cross member shall be a double channel manufactured assembly such as Unistrut P1001, B-Line B22A, Superstrut A-1202, or equal. Pipe attachments shall be Type 13s or Type 7s specified in paragraph 2.03 Pipe Attachments. Rod stiffeners and lateral brace shall be as specified in paragraph 2.03 Braces and Fittings.
4. Type 22s: Double Channel Longitudinal Restraint: Trapeze restraint cross member shall be a double channel manufactured assembly such as Unistrut P1001, B-Line B22A, Superstrut A-1202, or equal. Pipe attachments shall be Type 13s or Type 7s specified in paragraph 2.03 Pipe Attachments. Rod stiffeners, longitudinal and lateral braces shall be as specified in paragraph 2.03 Braces and Fittings.

D. Braces and Fittings:

1. Seismic Brace Fitting: Seismic brace fitting shall be manufactured for use with industry standard framing channel. The fitting shall be carbon steel, welded construction, two-piece linked fitting. A means to reduce noise and vibration transmission between the linked fitting parts shall be provided. Seismic brace fittings shall be Superstrut C-749N series seismic brace, Kin-Line No. 633 seismic connector fitting, or equal.
2. Hanger Rod Stiffener Assembly: Rod stiffener channel shall be 1 5/8-inch square carbon steel framing channel, Unistrut P1000, B-Line B22, Superstrut A-1200, or equal. Rod stiffener clamps shall be complete with channel nut and shall be Superstrut ES-142, Kin-Line No. 635, or equal.
3. Type A1 Seismic Brace: Seismic brace shall be 1 5/8-inch square carbon steel framing channel, Unistrut P1000, B-Line B22, Superstrut A-1200, Kin-Line No. 4112, or equal.
4. Type A2 Seismic Brace: Seismic brace shall be 1 5/8-inch wide by 3 1/4-inch deep carbon steel framing channel, Unistrut P5000, B-Line B11, Superstrut H-1200, Kin-Line No. 8212, or equal.

E. Structural Attachments:

1. General: Unless otherwise specified, hanger rod structural attachments shall be as specified in Section 40 05 07. Structural attachments for longitudinal and lateral seismic braces shall be as specified in paragraph 2.03 Structural Attachments.
2. Type SA-1 Attachment: Brace fitting shall be as specified in paragraph 2.03 Braces and Fittings. Concrete anchors shall be as specified in Section 05 05 20 with embedment and location dimensions as specified.

3. Type SA-2 Attachment: Brace fitting shall be as specified in paragraph 2.03 Braces and Fittings. Concrete anchors shall be as specified in Section 05 05 20 with embedment and location dimensions as specified. Framing channel shall be as specified in paragraph 2.03 Accessories.
4. Type SA-3 Attachment: Brace fitting shall be as specified in paragraph 2.03 Braces and Fittings. Cap screw, lockwasher and hex nut materials and finish shall be compatible with structural steel material.

F. Accessories:
1. Hanger Rods: Rods shall be carbon steel, threaded on both ends or continuous threaded and sized as specified.
2. Framing Channel: Framing channel shall conform to the Metal Framing Manufacturers Association standard MFMA-1. Framing channel shall be roll formed, 12-gage carbon steel. Channel shall have a continuous slot along one side with in-turned clamping ridges. Channel shall be Unistrut P1000 series, B-Line B22 series, Superstrut A-1200 series, or equal.
3. Rod Coupling: Rod coupling shall be carbon steel, with sight hole in center of coupling body, Grinnell Fig. 135, Superstrut H-119, or equal.

G. Thermal Pipe Hanger Shield
1. Thermal shields shall be provided at seismic restraint locations on pipe requiring insulation. Thermal pipe hanger shields shall be as specified in Section 40 05 07. Stainless steel band clamps shall be provided on thermal shields at longitudinal pipe restraint locations.

PART 3 EXECUTION

3.01 PIPE RESTRAINT LOCATIONS

A. The first seismic restraint on a piping system shall be located not more than 10 feet from the main riser, entrance to a building or piece of equipment.

B. Cast iron pipe shall be braced on each side of a change in direction of 90 degrees or more. Joints in risers shall be braced or stabilized between floors.

C. No-hub and bell and spigot cast iron soil pipe shall be braced longitudinally every 20 feet and laterally every 10 feet.

D. Lateral bracing for one pipe section may also act as longitudinal bracing for the pipe section connected perpendicular to it, if the bracing is installed within 24 inches of the elbow or tee of the same size.

E. Seismic restraint locations and components shall be indicated on the piping layout drawings required by Section 40 05 01. The Contractor shall provide a legend giving load information and restraint component selection at each restraint location.

3.02 INSTALLATION

A. Rod stiffener assemblies shall be used at seismic restraints for hanger rods over 6 inches in length. A minimum of two rod stiffener clamps shall be used on any rod stiffener assembly.

B. Lateral and longitudinal bracing shall be installed between 45 degrees above and 45 degrees below horizontal, inclusive, relative to the horizontal centerline of the pipe.

C. Welded and bolted attachments to the building structural steel shall be in accordance with the requirements of the AISC Manual of Steel Construction. There shall be no drilling or burning of holes in the building structural steel without approval of the Construction Manager.

D. Embedded anchor bolts shall be used instead of concrete inserts for seismic brace installations in areas below water surface or normally subject to submerging.

E. The Contractor shall install thermal pipe hanger shields on insulated piping at required locations during restraint installation. Butt joint connections to pipe insulation shall be made at the time of insulation installation in accordance with the manufacturer's recommendations.

F. Restraint components in contact with plastic pipe shall be free of burrs and sharp edges.

G. Rollers shall roll freely without binding.

H. Plastic or rubber end caps shall be provided at the exposed ends of all framing channels that are located up to 7 feet above the floor.

END OF SECTION

SECTION 40 05 07.16

EXPANSION CONTROL FOR PIPING

PART 1 GENERAL

1.01 SUMMARY

A. This section specifies expansion control for the piping systems specified in paragraph 2.01 Service Requirements. This section addresses pipe anchorage, pipe guides, and expansion control by either expansion joints or pipe deflection.

B. All expansion control components shall be as specified on the Drawings and this Section.
   1. Section 40 05 45 – Piping System Identification
   2. Section 40 42 00 – Insulation for Exposed Piping and Equipment

1.02 REFERENCES

A. This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section prevail.

Reference	Title
AISC Manual of Steel Construction	American Institute of Steel Construction, Manual of Steel Construction, Allowable Stress Design - 9th Edition
EJMA-93	Standards of the Expansion Joint Manufacturers Association, Inc., Sixth Edition, 1993
EJMA-85	A Practical Guide to Expansion Joints, Copyright 1985, Expansion Joint Manufacturers Association, Inc.

1.03 DEFINITIONS:

Term	Definition
Expansion joint	Any device containing one or more bellows used to absorb dimensional changes.
Main anchor	An attachment between a structure and a pipe which must withstand the full pipeline thrust due to pressure, pipe bending, pipe compression, flow, spring forces, pipe and contents weight and other pipe forces.
Intermediate anchor	An attachment between a structure and a pipe which withstands the same forces as a main anchor except the pressure forces.
Sliding anchor	An attachment between a structure and a pipe which absorbs forces in one direction while permitting motion in another.
Pipe guide	A device fastened to a structure, which permits the pipeline to move freely in only one direction, along the axis of the pipe.
Pipe section	That portion of pipe between two anchors.
Planar pipe guide	A device fastened to a structure, which permits transverse movement or bending of the pipeline in one plane.
Lateral direction	Direction perpendicular to the pipe axis
Longitudinal direction	Direction parallel to the pipe axis

Term	Definition
Thrust Tie	Attachments to expansion joints that allow joint to accommodate axial thrust due to internal pressure

1.04 ADMISTRATIVE REQUIREMENTS

A. Cordination:
   1. Coordinate expansion control systems shown on Drawings with hanger and support systems and seismic restraints.
   2. The piping system layout Drawings specified in Section 40 05 01 show the anchor and expansion control locations as well as the details of the supports, hangers and the seismic restraints.

1.05 SUBMITTALS

A. Action Submittals:
   1. Procedures: Section 01 33 00.
   2. A copy of this Section, addendum updates included, with each paragraph check-marked to indicate compliance or marked to indicate requested deviations.
   3. Identify expansion control locations and components indicated on piping layout drawings as specified in Section 40 05 01.

B. Information Submittals:
   1. Procedures: Section 01 33 00.
   2. Anchor bolt calculations in accordance with Section 05 05 20 requirements.

1.06 QUALITY ASSURANCE

A. Refer to Section 40 05 01 for additional quality assurance requirements.

1.07 DELIVERY, STORAGE, AND HANDLING

A. Procedures: Section 01 66 00.

B. Additional requirements: 40 05 01.

PART 2 PRODUCTS

2.01 PERFORMANCE/ DESIGN REQUIREMENTS

A. Service Conditions:
   1. This Section specifies minimum operating temperatures for piping services designed to operate at temperatures below ambient conditions and specifies maximum operating temperatures for piping services designed to operate at temperatures above ambient conditions. Piping services not listed in this Section operate within ambient temperature range. For the purposes of installing pipe hangers, supports, seismic, bracing, and expansion control components, ambient temperature conditions are defined as 60 to 120 degrees Fahrenheit.

Piping system	Minimum temperature, degrees F	Maximum temperature, degrees F
HW, HPHW	17 (exterior –20)	300 (exterior 200)
FA	30 (exterior –20)	120
Unlisted Piping (exterior)	-20	120
Unlisted Piping (interior)	30	120

2. Until completion of commissioning, the Contractor is responsible for protecting piping systems against damage resulting from expansion or contraction of pipe materials exposed to temperatures outside the temperature range between ambient temperature conditions and operating temperature conditions.

B. Design:

1. Expansion control as specified in this section and as specified on the Drawings control pipe movements and loads occurring as a result of pipeline temperature changes.
2. Provide expansion control as specified on the Drawings. Where anchors and expansion joints are not specified on the Drawings, expansion control is to be provided through deflection of the piping and pipe fittings. Where expansion control is provided through deflection of the piping and pipe fittings, support and brace piping such that thermal expansion movement is accommodated without application of excessive loads to piping, supports and bracing. Where expansion “U” loops are identified on the Drawings, weld all “U” loop elbows and piping connections. Weld piping connections at elbows within 10 diameters from an anchor.
3. Expansion control provisions are specified in Drawings and Specifications as necessary to accommodate expansion and/or contraction of pipe materials as a result of temperature changes between ambient temperature conditions and operating temperature conditions. Pipe hangers and supports shall be installed to accommodate expansion/contraction without interfering with expansion control functions. Following commissioning of piping systems, adjust pipe supports and hangers as necessary for proper installation at operating temperatures.

2.02 MATERIALS

A. Unless otherwise specified, anchors, and guides shall be manufactured of iron or steel, including braces, pipe and structural attachments, and shall be hot-dip galvanized after fabrication. Supports cast integrally with cast iron fittings are specifically prohibited for use in any application where shear forces may be imposed on the support.

B. Structural anchors may be fabricated from structural steel and coated as specified in Section 09 90 00.

C. Nuts, bolts and washers may be zinc-plated except for those subject to moisture or corrosive atmosphere, as specified in Section 01 61 45 Area Exposure Designations, which shall be Type 304 stainless steel.

D. Also listed in Section 26 05 00-1.05 Hazardous (Classified) Areas are corrosive areas specifically requiring fiberglass materials. In those areas, all pipe support, anchor and brace components (not just fittings and accessories) shall be made of fiberglass.

PART 3 EXECUTION

3.01 GENERAL

A. Furnish and install the expansion control system components as specified in the Drawings and as specified within this Section and in related Sections.

B. Provide expansion control as specified on the Drawings and Section 40 05 06.23.

3.02 INSTALLATION

A. Install expansion control, pipe support and seismic restraints to provide maximum flexibility for maintenance access to equipment, appurtenances such as valves etc., and to the pipe itself.

B. Metal-to-metal contact between a pipe and pipe anchor of dissimilar metals is not permitted.

C. Where pipe guides are specified on the Drawings, furnish and place them as specified and fasten them to structures to provide the maximum vertical and lateral load capacity of the specified pipe guides.

D. Install the expansion control system in accordance with the drawings requirements specified in this Section.

E. Weld and bolt attachments to the building structural steel in accordance with the requirements of the AISC Manual of Steel Construction (allowable stress design). No drilling or burning of holes in the building structural steel is allowed without approval of the Construction Manager.

F. Provide embedded anchor bolts instead of concrete inserts, wedge anchors, expansion anchors, adhesive, or other non-embedded type of anchor for expansion control installations in areas below water surface or normally subject to submergence. Anchor bolt installation as specified in Section 05 50 20.

G. Install thermal pipe hanger shields on insulated piping at required locations during guide installation. Butt joint connections to pipe insulation shall be made at the time of insulation installation in accordance with the manufacturer's recommendations.

H. Connect anchors directly to the pipe as specified on the Drawings and details.

I. Components in contact with plastic pipe shall be free of burrs and sharp edges.

J. Provide plastic or rubber end caps at the exposed ends of all framing channels that are located up to 7 feet above the floor.

END OF SECTION

SECTION 40 05 19

DUCTILE IRON PIPE

PART 1 GENERAL

1.01 SUMMARY

A. This Section specifies ductile iron pipe and fittings.

1.02 RELATED SECTIONS

A. Section 01 33 00 – Submittal Procedures

B. Section 01 66 00 – Product Storage and Handling Requirements

C. Section 40 05 01 – Piping Systems

D. Section 40 05 02 – Piping System Schedules

1.03 REFERENCES

A. This section and the corresponding Piping System Schedules (Section 40 05 02) contain references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.

Reference	Title
ASME B16.1	Cast Iron Pipe Flanges and Flanged Fittings Class 25, 125, and 250
ASME B16.5	Pipe Flanges and Flanged Fittings
ASTM B1000	Casting Preparation and Test Procedure of Porcelain Enamel-lined Pipe, Fittings, and Valves for Use in the Municipal Wastewater, Sewage, and Water Treatment Industry
ASTM C150	Portland Cement
ASTM A716	Standard Specification for Ductile Iron Culvert Pipe
AWWA C104	Cement-Mortar Lining for Ductile- Iron and Gray-Iron Pipe
AWWA C105	Polyethylene Encasement for Ductile-Iron Pipe Systems
AWWA C110	Ductile-Iron and Gray-Iron Fittings
AWWA C111	Rubber-Gasket Joints for Ductile- Iron and Gray-Iron Pressure Pipe and Fittings
AWWA C115	Flanged Ductile-Iron and Gray-Iron Pipe with Threaded Flanges
AWWA C116	Protective Fusion-Bonded-Epoxy Coating for the Interior and Exterior Surfaces for Ductile-Iron and Gray-Iron Fittings.
AWWA C150	Thickness Design of Ductile-Iron Pipe
AWWA C151	Ductile-Iron Pipe, Centrifugally Cast
AWWA C153	Ductile-Iron Compact Fittings
AWWA C600	Installation of Ductile-Iron Water Mains and Their Appurtenances.
AWWA C606	Grooved and Shouldered Type Joints
ISO 8179-1	Ductile Iron Pipes – Externa Zinc-based Coating - Part 1: Metallic Zinc with Finishing Layer

1.04 SUBMITTALS

A. Action Submittals:
   1. Procedures: Section 01 33 00
   2. A copy of this specification section, with addendum updates included, and all referenced and applicable sections, with addendum updates included, with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements. Check marks (✓) denote full compliance with a paragraph as a whole. If deviations from the specifications are indicated, each deviation shall be underlined and denoted by a number in the margin to the right of the identified paragraph, referenced to a detailed written explanation of the reasons for requesting the deviation. The Construction Manager is the final authority for determining acceptability of requested deviations. The remaining portions of the paragraph not underlined will signify compliance with the specifications. Failure to include a copy of the marked-up specification sections, along with justification(s) for any requested deviations to the specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration.
   3. Manufacturer's product data, catalog cuts, dimensions and materials. Indicate each Piping System Schedule where the product will be used.

B. Informational Submittals:
   1. Procedures: Section 01 33 00
   2. Certifications indicated in the following documents:
      a. ASTM A716, sworn statement of inspection and certification
      b. AWWA C110, certification of inspection and testing
      c. AWWA C111, record of specified tests
      d. AWWA C115, affidavit of compliance
      e. AWWA C151, manufacturer’s statement and affidavit of compliance
      f. AWWA C606, affidavit of compliance

1.05 DELIVERY, STORAGE, AND HANDLING

A. Procedures: Section 01 66 00 for shipment and storage.

B. Lift and handle glass lined pipe from the exterior of the pipe. Lifting or handling glass lined pipe using hooks, forks, or chains in contact with the interior of the pipe is not permitted.

PART 2 PRODUCTS

2.01 MATERIALS

A. All pipe system materials to be new, free from defects and conforming to the requirements and standards identified in Section 40 05 02 and related sections.

B. Pipe.
   1. Provide increased wall thickness where specified on the Drawings.

2.02 PIPE AND FITTING LINING

A. Provide pipe and fittings with lining as specified in Piping System Schedules in Section 40 05 02.00 through 40 05 02.99. Requirements for each lining type are specified in this Section.
   1. Not Used
   2. Glass Lining
      a. Factory or Shop applied per ASTM B1000 and lining manufacturer's recommended installation procedures.
      b. Prepare pipe pipe and fittings per ASTM B1000. Bore, machine, or grit blast pipe to remove any voids, protrusions or surface irregularities and to obtain a smooth continuous surface for glass lining. Grind or grit blast fittings to remove any voids, protrusions or surface irregularities.
      c. Line pipe and fittings with glass lining, 10 mils minimum thickness, using a dual layer coating system of vitreous material conforming to ASTM B1000.
      d. Provide continuous coverage glass lining as tested by a low voltage holiday detector with only isolated voids permitted due to casting anomalies. Voids, other than isolated pinholes, shall be cause for rejection. Maximum holiday indications limiter per ASTM B1000.
      e. Damaged glass lining cannot be repaired. Cut or damaged glass lined pipe must be replaced.
      f. Candidate manufacturers:
         1) Ferrock, MEH 32
         2) Vitco SG 14
         3) CBGL911
         4) Approved equal
   3. Ceramic Epoxy
      a. Factory applied per manufacturer's recommendations.
      b. Line pipe and fittings with amine cured novolac epoxy containing at least 20 percent ceramic quartz pigment.
      c. 40 mils minimum thickness
      d. Candidate Manufacturers:
         1) Protecto 401
         2) Approved equal
   4. Unlined
      a. Provide pipe and fittings with a bare metal (no coating) interior.

2.03 PIPE AND FITTING COATING

A. Provide pipe with coating as specified in Piping System Specification Sheets in Section 40 05 02. Requirements for each coating type are specified in this Section.
   1. Zinc Coating with Asphaltic Top Coat
      a. Factory applied
      b. Coat pipe and fittings with a layer of arc-sprayed zinc per ISO 8179-1. Zinc applied at not less than 200 g/m^2 of pipe surface area. Apply a finishing layer asphaltic topcoat per AWWA C151.

2. Polyethylene Encasement
    a. Field installed
    b. Encase pipe and fittings in polyethylene wrap as specified in AWWA C105.
    c. Polyethylene tubing shall be Anti-microbial, Low Density Polyethylene (LDPE) or High Density Polyethylene (HDPE):
        1) LDPE: 8-mil linear low density polyethylene film meeting the requirements of AWWA C105, impregnated with ½ percent NM-100 anti-microbial compound. Fulton Enterprises Biofilm, or Approved Equal.
        2) HDPE: 4-mil high-density, cross-laminated polyethylene film meeting the requirements of AWWA C105.
    d. Seam/Joint Tape – Acceptable manufacturer:
        1) Polyken No. 900 (polyethylene)
        2) Scotchwrap No. 50 (polyvinyl)
        3) Approved equal
3. V-Bio Enhanced Polyethylene Encasement
    a. Field installed
    b. Encase pipe and fittings in polyethylene tubing as specified in AWWA C105.
    c. Three layer, co-extruded, linear low density polyethylene wrap.
    d. 8 mils minimum wrap thickness
    e. Inner surface of polyethylene wrap infused with anti-microbial biocide and corrosion inhibitor.
    f. Candidate Manufacturers:
        1) Daubert Cromwell
        2) Approved Equal
4. Polyamidoamine Epoxy Primer
    a. Factory or shop applied
    b. Coat pipe and fittings with Amide or Polyamide cured epoxy, 4 to 8 mils DFT
6. Uncoated
    a. Provide pipe and fittings with a bare metal (no coating) exterior.

2.04 FUSION-BONDED EPOXY LINING AND COATING FOR PIPE AND FITTINGS

A. Factory or shop applied

B. Fusion Bonded Epoxy lining and coating per AWWA C116.

2.05 JOINTS AND COUPLINGS

A. Push-On (PO) Joint (Unrestrained)
    1. Rubber ring compression gasket, push-on type joints conforming to AWWA C111.
    2. 5 degree deflection at rated operating pressure for joints on 4-inch through 30-inch pipe.

3. Candidate manufacturers:
    a. American Cast Iron Pipe Company Fastite
    b. U.S. Pipe Tyton Joint
    c. Approved equal

B. Restrained Push-On (RPO) Joint
    1. Restrained, rubber ring compression gasket, push-on joints conforming to AWWA C111
    2. Restrained by the interference of metallic rings, bolts, locking segments or other interlocking components with flanges, lugs, beads, grooves or retainer rings that are integrally cast into or welded onto both ends of the joint. Restrained joints with gripping wedges, or gripping gaskets, radial pads, or other devices that penetrate, grip, or embed in the pipe material to resist axial thrust loads are not acceptable.
    3. Candidate manufacturers:
        a. American Cast Iron Pipe Company, Flex-Ring or Lok-Ring
        b. U.S. Pipe, TR Flex or HP LOK
        c. Approved equal

C. Mechanical Joint (MJ)
    1. Mechanical Joints per AWWA C110 and AWWA C111

D. Restrained Mechanical Joint (RMJ)
    1. Restrained by tie-rods/bolts tying the gasket gland to a second retainer/follower gland behind a welded ring on the spigot end of the joint. Restrained joints with gripping wedges, or gripping gaskets, radial pads, or other devices that penetrate, grip, or embed in the pipe material to resist axial thrust loads are not acceptable.
    2. Fully restrained mechanical joints for above or below ground service conforming to AWWA C110 and AWWA C111.
    3. Candidate manufacturers:
        a. American Cast Iron Pipe Company, Mechanical Joint Coupled Joint
        b. U.S. Pipe, BOLT-LOK or MECH-LOK
        c. Approved equal

E. Grooved couplings (CGRV) and fittings
    1. Cast or cut groove dimensions per AWWA C606
    2. Flexible or Rigid Couplings as specified in the Piping System Schedules (Sections 40 05 02.00 through 40 05 02.99).
    3. When pipe wall thickness does not meet the minimum requirements of AWWA C606 for rolled or cut groove joints, provide shouldered ends per the requirements of AWWA C606.
    4. Candidate manufacturers:
        a. Victaulic
        b. Gruvlok
        c. Approved equal

5. Grooved end flanged coupling adapters candidate manufacturers:
    a. Victaulic Style 341
    b. Approved equal
6. Grooved end transition couplings to steel pipe candidate manufacturers:
    a. Victaulic Style 307
    b. Approved equal

F. Ring Joint Coupling (RJC):
1. Circumferential coupling segments bolted together to engage shouldered end or ring adpapters. Groove dimensions per coupling manufacturer's requirements.
2. Flexible or Rigid Couplings as specified in the Piping System Schedules (Sections 40 05 02.00 through 40 05 02.99).
3. When pipe wall thickness does not meet the minimum requirements for the specified groove joint(s), provide shoulder ends or ring adapters welded to pipe ends.
4. Candidate manufacturers:
    a. Victaulic Vic-Ring
    b. Approved equal

G. Bell and Ball Spigot Flexible (BABS) Joint
1. Boltless type with retainer lock to prevent rotation after assembly
2. Up to 15 degrees of deflection at operating pressure
3. Candidate manufacturers:
    a. Flex-Lok Joint by American Cast Iron Pipe
    b. USIFlex by US Pipe
    c. Approved equal

H. Sleeve/Transition Coupling
1. When connecting new ductile iron piping to existing piping, field verify outside diameters of existing pipe prior to connection. See drawings for location and installation requirements.
2. Candidate Manufacturers:
    a. Romac, "501"
    b. JCM, "212"
    c. Smith-Blair, "461"
    d. Approved equal

PART 3 EXECUTION

3.01 INSTALLATION

A. General:
1. Follow piping routes specified on the drawings as closely as possible. Submit proposed deviations in accordance with Section 01 33 00.
2. Install pipe in accordance with AWWA C600.

3. Make connections to existing structures and manholes so that the finished work will conform as nearly as practicable to the requirements specified for new manholes, including necessary concrete work, cutting and shaping. Shape concrete mortar within any structure and manhole as specified.

B. Insulating Sections: Where a metallic nonferrous pipe/appurtenance connects to ferrous pipe/appurtenance, provide an insulating section per Section 40 05 06.

C. Anchorage: Provide as specified on the Drawings.

3.02 REPAIR/RESTORATION

A. Per Section 40 05 01

3.03 COMPONENT TEST PHASE

A. Buried Piping: Test hydrostatic pressure in accordance with Section 5 of AWWA C600, using the test pressures and allowable leakage specified in Section 40 05 01.

B. Exposed and Concrete Encased Piping: Conduct hydrostatic pressure tests in accordance with Section 40 05 01.

3.04 POLYETHYLENE ENCASEMENT

A. Install polyethylene as specified in AWWA C105 and within this Section.

B. Wrapping:
   1. Wrap buried pipe, fittings, valves, and couplings.
   2. Prior to the placing of concrete, wrap fittings that require concrete backing.
   3. Wrap the polyethylene tube seams and overlaps and hold in place by means of a 2-inch-wide plastic backed adhesive tape.
   4. The tape shall be such that the adhesive shall bond securely to both metal surfaces and polyethylene film.
   5. Bedding and initial backfill for polyethylene wrapped pipe shall be a well-graded granular material to avoid cutting or damaging the polyethylene tube during placement and backfilling.

END OF SECTION

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SECTION 40 05 24

STEEL PROCESS PIPE

PART 1 GENERAL

1.01 SUMMARY

A. This section specifies steel pipe and fittings.

1.02 RELATED SECTIONS

A. This Section contains specific references to the following related sections. Additional related Sections may apply that are not specifically listed below.
   1. Section 40 05 01 – Piping Systems
   2. Section 40 05 06 – Specialty Couplings and Adapters for Process Piping

1.03 REFERENCE STANDARDS

A. This Section contains references to the following documents. Those documents are a part of this Section as specified and modified. In the event of conflict between the requirements of this Section and those of the listed documents, the requirements of this Section shall prevail.

B. Unless otherwise specified, references to documents shall mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid (or on the effective date of the Agreement if there was no Bids). If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued. Where document dates are given in the following listing, references to those documents shall mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, discontinued or replaced. In all cases, the effective version of the local building code at the time of Advertisement for Bids or Invitation to Bid shall be considered the building code in effect.

Reference	Title
ANSI B16.3	Malleable Iron Threaded Fittings, Class 150 and 300
ANSI B16.9	Factory-Made Wrought Steel Buttwelding Fittings
ANSI B16.11	Forged Steel Fittings, Socket-Welding and Threaded
ASTM A36/A36M	Structural Steel
ASTM A47	Ferritic Malleable Iron Castings
ASTM A53	Pipe, Steel, Black and Hot-Dipped, Zinc-Coated Welded and Seamless
ASTM A105/A105M	Forgings, Carbon Steel, for Piping Components
ASTM A106 REV A	Seamless Carbon Steel Pipe for High-Temperature Service
ASTM A197	Cupola Malleable Iron
ASTM A234/A234M	Pipe Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and Elevated Temperatures
ASTM A283/A283M REV A	Low and Intermediate Tensile Strength Carbon Steel Plates, Shapes and Bars
ASTM A536	Ductile Iron Castings

Reference	Title
ASTM A570/A570M	Hot-Rolled Carbon Steel Sheet and Strip, Structural Quality
ASTM A572/A572M REV B	High Strength Low Alloy Columbium-Vanadium Steels of Structural Quality
AWWA C200	Steel Water Pipe 6 Inches and Larger
AWWA C205	Cement-Mortar Protective Lining and Coating for Steel Water Pipe–4 In. and Larger– Shop Applied
AWWA C206	Field Welding of Steel Water Pipe
AWWA C207	Steel Pipe Flanges for Waterworks Services–Sizes 4 In. Through 144 In.
AWWA C208	Dimensions for Fabricated Steel Water Pipe Fittings
AWWA C209	Cold-Applied Tape Coating for Special Sections, Connections, and Fittings for Steel Water Pipelines
AWWA C210	Liquid Epoxy Coating Systems for the Interior and Exterior of Steel Water Pipe
AWWA C214	Tape Coating Systems for the Exterior of Steel Water Pipelines
AWWA C600	Installation of Ductile-Iron Water Mains and Their Appurtenances
AWWA M11	Steel Pipe–A Guide for Design and Installation
SSPC-SP10	Near-White Blast Cleaning

1.04 QUALITY ASSURANCE

A. Testing:
   1. Factory testing shall conform to the requirements of ASTM A53, ASTM A106, or AWWA C200 as applicable.

PART 2 PRODUCTS

2.01 PIPE MATERIALS

A. Steel pipe and fittings shall be provided in accordance with ASTM A53, ASTM A106, or AWWA C200 as specified in Section 40 05 01.

B. Steel for pipe fabricated to meet requirements of AWWA C200 shall conform to the requirements of ASTM A36, ASTM A572, Grade 42, ASTM A570, Grades 33 and 36, or ASTM A283, Grade D. Steel for ASTM A53 and ASTM A106 pipe shall be Grade B.

2.02 PIPE MANUFACTURE

A. Unless otherwise specified, ASTM A53 pipe shall be Type E, electric resistance welded or Type S, seamless pipe as specified in Section 40 05 01. The minimum wall thickness for ASTM A53 or ASTM A106 pipe shall be Schedule 40 for pipe 10 inch diameter and less and 3/8 inch for pipe 12 inch through 24 inch diameter. Increased shell thickness shall be provided where specified.

B. AWWA C200 pipe shall be straight or spiral seam. The minimum wall thickness shall be 7 gage for pipe 6 inch through 24 inch diameter and 1/4 inch for pipe 26 inch diameter and larger. Increased shell thickness shall be provided where specified.

2.03 CONNECTIONS

A. Connections shall be as specified in Section 40 05 01 and shall conform to Section 40 05 06. Coating for buried connections shall be as specified in Section 40 05 06-2.06.

2.04 FITTINGS AND APPURTENANCES

A. Malleable iron threaded fittings and appurtenances shall conform to the requirements of ASTM A47 or ASTM A197, ANSI B16.3.

B. Unless otherwise specified, steel fittings and appurtenances shall conform to the requirements of ASTM A234, ASTM A105, or ANSI B16.11; and fabricated steel fittings and appurtenances shall conform to AWWA C208.

C. Fittings for grooved end piping systems shall be full flow cast fittings, steel fittings, or segmentally welded fittings with grooves or shoulders designed to accept grooved end couplings. Cast fittings shall be cast of ductile iron conforming to ASTM A536 or malleable iron conforming to ASTM A47. Standard steel fittings, including large size elbows, shall be forged steel conforming to ASTM A106. Standard segmentally welded fittings shall be fabricated of Schedule 40 carbon steel pipe.

D. Unless otherwise specified, all fittings shall be rated for pressure and loadings equal to the pipe.

2.05 PIPE LINING

A. Epoxy:
   1. Unless otherwise specified, pipe and fittings shall be lined with a liquid epoxy as specified in AWWA C210 with the following exceptions:
      a. No coal tar products shall be incorporated in the liquid epoxy.
      b. The curing agent may be an amidoamine as well as the other curing agents listed in AWWA C210.
   2. The lining shall be applied to a minimum thickness of 16 mils in not less than two coats.

B. Cement Mortar:
   1. Where specified, pipe and fittings shall be lined with cement mortar as specified in AWWA C205. Fittings and specials larger than 24 inches, not fabricated from centrifugally lined straight sections, shall require 2-inch by 4-inch by 13-gage self-furring wire mesh reinforcement for hand-applied lining.

C. High Temperature Service Epoxy:
   1. Where specified, steel pipe and fittings shall be epoxy lined with not less than 10 mils of epoxy suitable for temperatures of 225 degrees F. Epoxy lining shall be 3M Scotchkote 306, Porter MCR 65 High Solids Epoxy, or equal. Surfaces shall be prepared in accordance with SSPC-SP 10 Near White Blast Cleaning, and the lining applied as recommended by the manufacturer.

D. Glass Lining:
   1. Where specified, pipe and fittings shall be glass lined with a dual layer coating system of vitreous material to a minimum thickness of 10 mils. Glass lining shall provide continuous coverage as tested by a low voltage holiday detector with only isolated voids permitted due to casting anomalies. Voids, other than isolated pinholes, shall be cause for rejection.

2. Pipe and fittings shall have all internal welds ground smooth and any voids or slag holes ground out, rewelded and ground smooth.
3. Glass lining shall be Ferrock MEH-32, Vitco SG-14, or equal.

2.06 PIPE COATING

A. Epoxy:
1. Unless otherwise specified, pipe and fittings shall be coated with a liquid epoxy as specified in AWWA C210 with the following exceptions:
a. No coal tar products shall be incorporated in the liquid epoxy.
b. The curing agent may be an amidoamine as well as the other curing agents listed in AWWA C210.
2. The coating shall be applied to a minimum thickness of 16 mils in not less than two coats.

B. Polyethylene Tape:
1. Where specified, pipe and fittings shall be coated and wrapped with prefabricated multilayer cold applied polyethylene tape coating in accordance with AWWA C214. The coating application shall be a continuous step operation in conformance with AWWA C214, Section 3. The total coating thickness shall be not less than 50 mils for pipe 24 inches and smaller and not less than 80 mils for pipe 26 inches and larger.

2.07

2.07 FUSION EPOXY COATING AND LINING

A. Where specified, steel pipe and fittings shall be fusion epoxy coated and lined. The fusion epoxy coating shall be 3M Scotchkote 203, or equal. Surface preparation shall be in accordance with SSPC-SP 10 Near White Blast Cleaning. The application method shall be by the fluidized bed method and shall attain 12 mils minimum dry film thickness.

B. Field welds, connections and otherwise damaged areas shall be coated and patched according to the manufacturer's instructions with 3M Scotchkote 306.

2.08 JOINT GASKETS (NOT USED)

2.09 PRODUCT DATA

A. The following information shall be provided in accordance with Section 01 33 00:
1. Affidavits of Compliance with AWWA C200, ASTM A53, or ASTM A106 as applicable.
2. Contractor's layout drawings as specified in Section 40 05 01-2.04.

PART 3 EXECUTION

3.01 INSTALLATION

A. General:
1. Pipe shall be installed in accordance with AWWA M11, Chapter 16. Welded joints shall be in accordance with AWWA C206 and Section 40 05 06.
2. Sleeve-type mechanical pipe couplings shall be provided in accordance with AWWA M11 and Section 40 05 06-2.02 Sleeve-Type Couplings.

3. Pipe lining and coatings at field joints shall be applied as specified in paragraphs 2.05 and 2.06.
4. Unless otherwise specified, buried mechanical couplings and valves shall be field coated as specified in Section 40 05 06-2.06.

B. Anchorage:
1. Anchorage shall be provided as specified. Calculations and drawings for proposed alternative anchorage shall be submitted in accordance with Section 01 33 00.

3.02 TESTING

A. Hydrostatic testing shall be in accordance with Section 4 of AWWA C600 except that test pressures and allowable leakage shall be as listed in Section 40 05 01.

END OF SECTION

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SECTION 40 05 31

THERMOPLASTIC PROCESS PIPE

PART 1 GENERAL

1.01 DESCRIPTION

A. Scope:

1. This section specifies polyvinylchloride, chlorinated polyvinylchloride, polyethylene, and polypropylene pipe and fittings.

B. Pipe Designations:

1. For use in the Piping System Specification Sheets in Section 40 05 01 and in this section, the following plastic pipe designations are defined:

Designation	Definition
PVC	Polyvinylchloride
CPVC	Chlorinated polyvinylchloride
PE	Polyethylene
PP	Polypropylene

1.02 QUALITY ASSURANCE

A. References:

1. This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.
2. Unless otherwise specified, references to documents shall mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid (or on the effective date of the Agreement if there were no Bids). If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued. Where document dates are given in the following listing, references to those documents shall mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, discontinued or replaced.

Reference	Title
ASTM D1248	Polyethylene Plastics Molding and Extrusion Materials
ASTM D1784	Rigid Poly (Vinyl Chloride) (PVC) Compounds and Chlorinated Poly (Vinyl Chloride) (CPVC) Compounds
ASTM D1785	Poly (Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, and 120
ASTM D2241	Poly (Vinyl Chloride) (PVC) Plastic Pipe (SDR-PR)
ASTM D2464	Threaded Poly (Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 80
ASTM D2466	Poly (Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 40

Reference	Title
ASTM D2467	Socket-Type Poly (Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 80
ASTM D2564	Solvent Cements for Poly (Vinyl Chloride) (PVC) Plastic Pipe and Fittings
ASTM D2657	Heat-Joining Polyolefin Pipe and Fittings
ASTM D2665	Poly (Vinyl Chloride) (PVC) Plastic Drain, Waste, and Vent Pipe and Fittings
ASTM D3034	Type PSM Poly (Vinyl Chloride) (PVC) Sewer Pipe and Fittings
ASTM D4101	Propylene Plastic Injection and Extrusion Materials
ASTM F402	Safe Handling of Solvent Cements and Primers Used for Joining Thermoplastic Pipe and Fittings
ASTM F437	Threaded Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe Fittings, Schedule 80
ASTM F438	Socket-Type Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe Fittings, Schedule 40
ASTM F439	Socket-Type Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe Fittings, Schedule 80
ASTM F441	Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe, Schedules 40 and 80
ASTM F477	Elastomeric Seals (Gaskets) for Joining Plastic Pipe
ASTM F493	Solvent Cements for Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe and Fittings

PART 2 PRODUCTS

2.01 PVC PIPE

A. Pressure Pipe:

1. PVC material for pipe and fittings shall conform to ASTM D1784, Class 12454-B. Pipe and fittings shall either be in accordance with ASTM D1785 or shall conform to ASTM D2241 for standard dimension ratios: 160 psi pipe–SDR 26; 200 psi pipe–SDR 21; 250 psi–SDR 17. Pressure rating for pipe shall be in excess of test pressure specified in Section 40 05 01. Neoprene gaskets with push-on joints shall conform to ASTM F477.
2. Schedule 80 PVC socket type fittings shall conform to ASTM D2467. Schedule 40 PVC fittings shall conform to ASTM D2466. PVC solvent weld cement for socket connections shall meet the requirements of ASTM D2564. Schedule 80 PVC threaded fittings shall conform to ASTM D2464. Fittings for gasketed pipe shall be ductile iron or steel push-on IPS-sized pressure fittings rated for use with the specified class of PVC pipe. Unless otherwise specified, fittings shall be lined and coated in accordance with Section 40 05 24.

B. Nonpressure Pipe:

1. Gravity Sewer Pipe: PVC material for sewer pipe and fittings shall conform to Class 12454-B, as defined in ASTM D1784. Pipe and fittings shall meet the requirements of ASTM D3034 for SDR 35. Neoprene gaskets with push-on joints shall conform to ASTM F477.
2. DRAIN, Waste and Vent Pipe: PVC material for drain waste and vent (DWV) pipe and fittings shall conform to Class 12454-B, ASTM D1784. Pipe and fittings shall conform to ASTM D2665. Unless otherwise specified, connections shall be solvent weld. Connections to traps, closet flanges, and nonplastic pipe shall be with approved adapter type fittings designed for intended use. Solvent weld cement for socket connections shall meet requirements of ASTM D2564.

2.02 CPVC PIPE

A. CPVC material for pipe and fittings shall conform to ASTM D1784, Class 23447-B. Pipe and fittings shall be in accordance with ASTM F441. Neoprene gaskets with push-on joints shall conform to ASTM F477.

B. Schedule 80 CPVC socket type fittings shall conform to ASTM F439. Schedule 40 CPVC socket type fittings shall conform to ASTM F438. CPVC solvent weld cement for socket connections shall meet the requirements of ASTM F493. Schedule 80 CPVC threaded type fittings shall conform to ASTM F437.

2.03 PE PIPE

A. PE pipe shall meet the requirements of ASTM D1248, Type III, Grade P 34, Class C, 100 psi or as specified in Section 40 05 01, whichever is higher. Fittings shall be of the same material, molded socket fusion for sizes 4 inch diameter and smaller and molded or fabricated butt fusion for sizes 6 inch and larger. Fittings shall be 125 psi or as specified in Section 40 05 01, whichever is higher. Heat fusion welding shall be in conformance with ASTM D2657.

2.04 PP PIPE

A. Pressure Pipe:
   1. PP pipe and fittings shall be formulated of polypropylene conforming to ASTM D4101, SDR 11, butt fusion type. Pipe shall be 150 psi rated in all sizes. Heat fusion welding shall be in conformance with manufacturer's recommendation.

B. Drain, Waste and Vent Pipe:
   1. PP drain, waste and vent (DWV) pipe and fittings shall be made from flame retardant, Schedule 40, polypropylene (PPFR) plastic as defined in ASTM D4101. Pipe and fittings used for buried piping and in concealed locations shall be joined by electrical fusion coils energized by a variable low-voltage power supply to completely fuse the interface between the pipe and socket and form a completely homogenous structure. Unless otherwise specified, mechanical joint fittings may be used under bench or in exposed locations where future disassembly is desired. The mechanical method shall be in conformance with the manufacturer's recommendation.

2.05 PRODUCT DATA

A. The following information shall be provided in accordance with Section 01 33 00:
   1. Manufacturer's certificates of compliance with the specified standards and Contractor's layout drawings.

PART 3 EXECUTION

3.01 INSTALLATION

A. PVC pipe 3 inches in diameter and smaller shall be joined by means of socket fittings and solvent welding in conformance with ASTM F402. Solvent-cemented joints shall be made in strict compliance with the manufacturer's/supplier's instructions and recommended procedures. Unless otherwise specified, PVC pipe 4 inches in diameter and greater shall be joined by means of gasketed push-on joints and steel or ductile iron push-on or mechanical joint fittings. Fittings shall be lined and coated as specified in Section 40 05 24. Unless otherwise specified, PVC and CPVC piping exposed to sunlight shall be painted with coating system L-2 as specified in Section 09 90 00.

B. Connections to different types of pipe shall be by means of flanges, specified adapters or transition fittings. Where sleeve type couplings are used, both shall be uniformly torqued in accordance with pipe manufacturer's recommendation. Foreign material shall be removed from the pipe interior prior to assembly.

C. Unless otherwise specified, PE pipe and fittings 4 inch diameter and smaller shall be joined by means of thermal socket fusion and pipe 6 inch and larger by thermal butt fusion. Butt-fusion joining of the pipes and fittings shall be performed with special joining equipment in accordance with procedures recommended by pipe manufacturer. Tensile strength at yield of butt-fusion joints shall not be less than pipe. Flanged adapters shall be provided for connection to valves and where specified.

3.02 TESTING

A. Testing of plastic piping shall be as specified in Section 40 05 01.

END OF SECTION

SECTION 40 05 31.13

SOLVENT CEMENT WELDED PVC AND CPVC PRESSURE PIPE

PART 1 GENERAL

1.01 SUMMARY

A. This Section specifies Polyvinylchloride (PVC) and Chlorinated Polyvinylchloride (CPVC) pipe and fittings with solvent cement welded or threaded connections/joints.

1.02 RELATED SECTIONS

A. This section contains specific references to the following related sections. Additional related sections may apply that are not specifically listed below.
   1. Section 01 33 00 – Submittal Procedures
   2. Section 09 90 00 – General Coating Specification
   3. Section 40 05 02 – Piping System Schedules

1.03 REFERENCES

A. This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.

Reference	Title
ASME B31.3	Process Piping
ASTM D1784	Rigid Poly (Vinyl Chloride) (PVC) Compounds and Chlorinated Poly (Vinyl Chloride) (CPVC) Compounds
ASTM D1785	Poly (Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, and 120
ASTM D2464	Threaded Poly (Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 80
ASTM D2466	Poly (Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 40
ASTM D2467	Socket Type Poly (Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 80
ASTM D2564	Solvent Cements for Poly (Vinyl Chloride) (PVC) Plastic Pipe and Fittings
ASTM D2855	Making Solvent-Cemented Joints with Poly (Vinyl Chloride) (PVC) Pipe and Fittings
ASTM F402	Safe Handling of Solvent Cements and Primers Used for Joining Thermoplastic Pipe and Fittings
ASTM F437	Threaded Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe Fittings, Schedule 80
ASTM F438	Socket Type Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe Fittings, Schedule 40
ASTM F439	Socket Type Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe Fittings, Schedule 80
ASTM F441	Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe, Schedules 40 and 80
ASTM F477	Elastomeric Seals (Gaskets) for Joining Plastic Pipe
ASTM F493	Solvent Cements for Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe and Fittings
ASTM F656	Primers for Use in Solvent Cement Joints of Poly (Vinyl Chloride) (PVC) Plastic
ASTM F1970	Special Engineered Fittings, Appurtenances or Valves for use in Poly (Vinyl Chloride) (PVC) or Chlorinated Poly (Vinyl Chloride) (CPVC) Systems

1.04 DEFINITIONS

A. Terminology used in this Section conforms to the following definitions:
   1. PVC: Polyvinylchloride
   2. CPVC: Chlorinated Polyvinylchloride

1.05 SUBMITTALS

A. Action Submittals:
   1. Procedures: Section 01 33 00.
   2. A copy of this specification section with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements. Check-marks (✓) denote full compliance with a paragraph as a whole. Underline deviations and denote each deviation with a number in the margin to the right of the identified paragraph. The remaining portions of the paragraph not underlined will signify compliance on the part of the Contractor with the specifications. Include a detailed, written justification for each deviation. Failure to include a copy of the marked-up specification section along with justification(s) for any requested deviations to the specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration.
   3. Piping layout drawings as specified in Section 40 05 01.
   4. Manufacturer's product data, catalog cuts, typical installation details, and dimensions. Indicate each Piping System Schedule where the product will be used.

1.06 DELIVERY, STORAGE AND HANDLING

A. Procedures: Section 01 66 00 for shipment and storage.

PART 2 PRODUCTS

2.01 MATERIALS

A. Provide PVC and CPVC piping system materials as specified in Piping System Schedules (Section 40 05 02.00 through Section 40 05 02.99) for the specified Process Service.

2.02 COMPONENTS

A. CPVC Solvent Weld Cement:
   1. Pipe and fittings 6-inch diameter and smaller: IPS 724 Weld-on Cement or Approved Equal.
   2. Pipe and fittings greater than 6-inch diameter: IPS 729 Weld-on Cement or Approved Equal.
   3. Heavy bodied, medium setting.
   4. ASTM F493, 100 percent solvent and CPVC resin. No fillers permitted.
   5. Universal plastic pipe solvent is not acceptable.
   6. Formulated for use with sodium hypochlorite solution and other caustic solutions.

B. PVC Solvent Weld Cement:
   1. Pipe and fittings 12-inch diameter and smaller: IPS 711 Weld-on Cement or Approved Equal.
   2. Pipe and fittings greater than 12-inch diameter: IPS 719 Weld-on Cement or Approved Equal.
   3. Heavy bodied, medium setting.
   4. ASTM 2564, 100 percent solvent and PVC resin. No fillers permitted.
   5. Universal plastic pipe solvent is not acceptable.

C. Primer:
   1. Staining solvent conforming to standard ASTM F656.
   2. Manufactured by solvent weld cement manufacturer.

PART 3 EXECUTION

3.01 INSTALLATION

A. Join by means of socket fittings and solvent cement welding in conformance with ASTM D2855 and ASTM F402.

B. Make solvent-cemented joints in strict compliance with the manufacturer's/supplier's instructions and recommended procedures.

C. Connections:
   1. Connect to different pipe materials by means of flanges, specified adapters, or transition fittings.
   2. Provide threaded by solvent-welded socket joint adapters at connections to equipment and appurtenances with threaded connections.
   3. Foreign material to be removed from the pipe interior prior to assembly.

D. Plastic pipe installation personnel trained to ASME B31.3.

E. Bedding and Backfill: As specified in Section [ ]. Blocking under pipe is not permitted.

3.02 FIELD QUALITY CONTROL

A. Conduct hydrostatic pressure tests in accordance with Section 40 05 01.

END OF SECTION

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SECTION 40 05 45

PIPING SYSTEM IDENTIFICATION

PART 1 GENERAL

1.01 SUMMARY

A. This section specifies the supply and installation of permanent identification labels and markers for piping systems.

B. Requirements for the supply and installation of permanent identification tags for valves are specified in Section 40 05 60 - Valves.

1.02 RELATED SECTIONS

A. This section contains specific references to the following related sections. Additional related sections may apply that are not specifically listed below.
   1. Section 01 33 00 – Submittal Procedures
   2. Section 01 61 45 – Area Exposure Designations
   3. Section 40 05 02 – Piping System Schedules
   4. Section 40 05 60 – Valves

1.03 REFERENCE STANDARDS

A. This Section contains references to the following documents. Those documents are a part of this Section as specified and modified. In the event of conflict between the requirements of this Section and those of the listed documents, the requirements of this Section shall prevail.

B. Unless otherwise specified, references to documents shall mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid (or on the effective date of the Agreement if there were no Bids). If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued. Where document dates are given in the following listing, references to those documents shall mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, discontinued or replaced.

Reference	Title
ANSI Z535.1	Safety Colors/APWA Uniform Color Code for Marking Underground Utilities
ASME A13.1	Scheme for the Identification of Piping Systems
MIL STD 810	Environmental Engineering Considerations and Laboratory Tests

1.04 DEFINITIONS

A. Terminology used in this Section conforms to the following definitions:
   1. Embedded/Encased piping: Piping enveloped in concrete, typically under structures or under roadways.

2. Exposed: All area exposures specified in Section 01 61 45 – Area Exposure Designations other than buried, submerged, or encased/embedded.
3. Buried: Below grade walls or roofs; locations covered and in contact with earth/soil.

1.05 SUBMITTALS

A. Submit the following minimum documentation per Section 01 33 00 - Submittal Procedures

B. Action Submittals: Submit the following prior to construction of this element of the Work.
1. A copy of this specification section, with addendum updates included, with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations. Checkmarks (✓) shall denote full compliance with a paragraph as a whole. Deviations shall be underlined and denoted by a number in the margin to the right of the identified paragraph. The remaining portions of the paragraph not underlined will signify compliance on the part of the Contractor with the specifications. Include a detailed, written justification for each deviation. Failure to include a copy of the marked-up specification sections, along with justification(s) for any requested deviations to the specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration
2. Provide a full line product brochure showing available Piping System Marker and Detectable Warning Tape standard text and color options. Submit all text and colors proposed for use.
3. Provide manufacturer's recommended installation instructions for Detectable Warning Tape.
4. Provide product brochures and data sheets for tracer wire and splice kits. Submit all wire insulation colors proposed for use.
5. Submit proposed tracer wire access box(es) for test leads. Submit electrical continuity test results upon completion.

C. Informational Submittals: Submit the following for inspection.
1. Electrical continuity test results.
2. Sample of each piping identification plastic marker used.
3. Sample of each detectable warning tape used.

PART 2 PRODUCTS

2.01 PIPING SYSTEM MARKERS FOR EXPOSED PIPE

A. Identify material contained in exposed piping systems using a colored plastic marker legend system conforming to ASME A13.1.

B. For exposed piping, provide pre-coiled mechanically attached type-colored markers that are easily removable. Adhesive type markers are not acceptable.
1. Resistant to petroleum-based oils and grease and meet criteria for humidity, solar radiation, rain, salt, fog, leakage and fungus specified by MIL STD 810.
2. Withstand a continuous operating temperature range of -40 to 250 degrees.

3. Manufactured and applied in one continuous length of plastic including directional arrows. Markers comprised of letters and directional arrows individually applied to the maker are not acceptable. Legends and arrows printed on polyester subsurface and over laminated with Tedlar.
4. Text size per ASME A13.1.
5. Marking Services Style MS-995, Brady Style B-689, or approved equal.

C. Each piping system marker to be color coded for identification and labelled with the Process Service Identifier and directional flow arrows indicating the direction of flow in the pipe. Piping System marker background colors are specified in Section 40 05 02 – Valves for each process service. Except for piping system markers with an orange, yellow or white background color, provide white text and directional arrows for all piping system markers. Provide black text and directional arrows for pipe markers with an orange, yellow or white background.

PART 3 EXECUTION

3.01 INSTALLATION OF PIPING SYSTEM MARKERS

A. Provide piping system markers and direction arrows at locations conforming to ASME A13.1 and at the following locations:
1. Apply intermittent markings on straight pipe runs, close to all valves, fittings, and adjacent to all changes in direction.
2. Where pipes pass through walls, partitions, and floors, apply markings on both sides of walls, partitions, and floors.
3. At point of entry and leaving each pipe chase and/or confined space and piping accessible at each access opening.
4. Adjacent to valves and where valves are in series at intervals of no more than 6 feet.
5. At least once in each room and at maximum spacing of 40 feet. Exception: gas piping to be identified at 6-ft intervals in ceiling plenums.
6. Spacing for markings not less than 1 foot.
7. At the beginning and end points of each run; and, at each piece of equipment in each run.

B. Visibility
1. Place identification on the bottom of the piping system for pipe systems located near ceiling or above the normal line of sight.
2. Place identification on the side of the piping systems for pipe systems located at the normal line of sight or below.
3. Place identification at approximate line of sight for vertical pipe systems.

3.02 INSTALLATION OF DETECTABLE WARNING TAPE

A. Install a continuous ribbon of Detectable Warning Tape as specified for ALL buried piping.

B. Multiple pipes less than 4 inches in diameter installed in a common trench may be provided with a single ribbon of tape per trench. If the total width of such utilities within the common trench exceeds 3 feet, provide two parallel ribbons of tape spaced equally.

C. Provide a separate detectable warning tape for each pipe that is 4 inches or greater in size.

D. Install the tape in accordance with manufacturer recommendations.

E. At end-to-end and branch connections, provide electrical continuity connectors for detectable tape to connect ends mechanically and electrically together as recommended by the manufacturer.

F. Provide a single line of tape 2.5 feet above the centerline of buried pipe. For pipelines buried 8 feet or greater below finished grade, provide a second line of tape 12 inches below finished grade, above and parallel to each buried pipe. Spread tape flat with message side up before backfilling.

3.03 INSTALLATION OF TRACER WIRE

A. Tracer wire shall be a continuous, fully functioning, and tested system to include all appurtenances including splices and wire access boxes at grade.

B. Tracer wire laid along the top of the pipe prior to backfilling. Secure in place with tape every 20 feet. Where the pipe is encased or provided with concrete collars or cut-off walls, lay the wire on top of the encasement (do not encase the wire). Do not pull the wire taut; leave sufficient slack to allow for pipe movement and future repairs.

C. Splice tracer wire using the specified silicone-filled splice kits in accordance with manufacturer recommendations. Ensure the silicone fully encapsulates un-insulated wire ends and are made watertight.

D. Pull tracer wire up into all valve boxes, cleanout access boxes, and into all utility cabinets and meter boxes installed on the pipeline. For each wire end, provide an 18-inch-long length of extra wire (coiled and tucked out of the way in an accessible location) for connection to utility locating equipment.

E. Where the pipeline enters structures, vaults, tanks, or buildings, provide a wire access box at grade adjacent to the structure or building for termination of the tracer wire. Provide an 18-inch-long length of extra wire (coiled and tucked into the box) for connection to utility locating equipment. Also provide boxes at each pipeline branch, cross or tee, and at intermediate spacing along the pipeline not to exceed 1,000 feet (except where pipeline valves with valve boxes provide the required wire access at those locations and intervals).

F. Upon completion and backfill of the pipeline, test, and demonstrate electrical continuity of each segment of tracer wire. Submit test results to the Owner indicating the location of the tested segment. Use conductive testing method; inductive test methods are not acceptable. Repair all faulty work at no additional cost to the Owner until the system is functional and approved.

3.04 FIELD QUALITY CONTROL

A. Comply with manufacturer's handling and installation instructions.

B. Provide continuity testing of tracer wire as specified herein.

END OF SECTION

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SECTION 40 05 57.13

MANUAL ACTUATORS

PART 1 GENERAL

1.01 DESCRIPTION

A. This section specifies manual operators for valves and gates, and operator appurtenances.

1.02 REFERENCES

A. This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.

B. Unless otherwise specified, references to documents shall mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid (or on the effective date of the Agreement if there were no Bids). If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued. Where document dates are given in the following listing, references to those documents shall mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, discontinued or replaced.

Reference	Title
AWWA C500	Gate Valves 3 through 48 inch NPS, for Water and Sewage Systems

PART 2 PRODUCTS

2.01 GENERAL

A. Except as specified in valve and gate specification sections, manual operators shall be as specified herein. Operators shall be mounted on the valve or gate and provided as a unit. Each valve body or operator shall have cast thereon the word "OPEN," an arrow indicating the direction to open, and flow direction arrows.

2.02 OPERATORS

A. General:

1. Manual operators shall have operating torques less than 80 foot-pounds. Unless specified otherwise, each manual operator shall be provided with an operating wheel. Unless specified otherwise, the direction of rotation of the operator shall be counterclockwise for opening.

B. Wrench Nuts:
   1. Wrench nuts shall comply with Section 3.15 of AWWA C500. A minimum of two operating keys, but no less than one key per every ten valves, shall be provided for operation of the wrench nut operated valves.

C. Chain Wheels:
   1. Chain wheels shall be ductile iron. Operating chains shall be galvanized.

2.03 OPERATOR APPURTENANCES

A. Valve Boxes:
   1. Valve boxes shall be cast iron and shall have suitable base castings to fit properly over the bonnets of their respective valves and heavy top sections with stay-put covers. Covers shall be hot-dip galvanized.

B. Floor Boxes:
   1. Floor boxes shall be hot-dip galvanized. Where the operating nut is in the concrete slab, the floor box shall be bronze bushed. Where the operating nut is below slab, the opening in the bottom of the box shall be sufficient for passage of the operating key.

C. Adjustable Shaft Valve Boxes:
   1. Adjustable shaft valve boxes shall be concrete or cast iron Brooks No. 3RT, Christie G5, Empire 7-1/2 valve extension box, or equal. Box covers on water lines shall be impressed with the letter "W." Gas line covers shall be impressed with the letter "G."

2.04 PRODUCT DATA

A. Manufacturer's catalog information and other data confirming conformance to design and material requirements shall be provided in accordance with Section 01 33 00.

PART 3 EXECUTION

3.01 GENERAL

A. Installation shall be as specified herein. Valve operators shall be located so that they are readily accessible for operation and maintenance. Valve operators shall be mounted for unobstructed access, but mounting shall not obstruct walkways. Valve operators shall not be mounted where shock or vibration will impair their operation. Support systems shall not be attached to handrails, process piping, or mechanical equipment.

3.02 OPERATORS

A. General:
   1. Valves and gates shall be provided with manual operators, unless specified otherwise. Where possible, manual operators shall be located between 48 inches and 60 inches above the floor or a permanent work platform.

B. Wrench Nuts:

1. Wrench nuts shall be provided on buried valves, on valves which are to be operated through floor boxes, and where specified. Extended wrench nuts shall be provided if necessary so that the nut will be within 6 inches of the valve box cover.

C. Chain Wheels:

1. Unless otherwise specified, valves with centerlines more than 7 feet, 6 inches above the specified operating level shall be provided with chain wheels and operating chains. Chain wheel operated valves shall be provided with a chain guide. Operating chains shall be looped to extend within 4 feet of the specified operating level below the valve. For plug-type valves 8 inches and larger, the operator shall be provided with a hammer blow wheel. Hooks shall be provided for chain storage where the chain may hang in a walkway.

3.03 OPERATOR APPURTENANCES

A. Valve Boxes:

1. Valve boxes extending to finished surfaces shall be provided for buried valves.

B. Floor Boxes:

1. Floor boxes shall be provided for wrench operation of valves located below concrete slabs. Each floor box and cover shall be of the depth required for installation in the slab.

END OF SECTION

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SECTION 40 05 60

VALVES

PART 1 GENERAL

1.01 SUMMARY

A. This Section specifies the supply, installation and testing of valves. Materials and performance requirements for valves are specified in Detailed Valve Specifications. Detailed Valve Specifications are provided in Sections 40 05 61.01 through 40 05 89.99. Additional Detailed Valve Specifications for some valves used for HVAC service are provided in Division 23.

B. Determining Valve Type:
   1. Drawings specify valve types (gate, plug, butterfly, check, globe, etc.) used in each pipeline. Process fluids that will be conveyed in pipelines are identified by the Process Service Identifiers shown on the Drawings.
   2. Piping System Schedules (Sections 40 05 02.01 through 40 05 02.99) specify piping system materials and components, including valve requirements, based on the Process Service Identifier specified on the Drawings for the pipeline or piping system. Piping System Schedules reference Detailed Valve Specifications that specify requirements for each valve type used in the pipeline or piping system.
   3. Provide valves conforming to the Detailed Valve Specifications listed in the Piping System Schedule for the valve/line size, process service, and valve type specified on the Drawings. Example: The Drawings specify a ball valve on a 1-inch line. The Piping System Schedule for the process service specified on the Drawings refers to Section 40 05 63.01 for 1/2 through 2 1/2 inch ball valves. For this example, provide the subject ball valve per the requirements specified in 40 05 63.01.

C. Section 40 06 20.13 specifies electric, pneumatic, and hydraulic powered control valves, complete with valve, actuator, and other ancillaries.

1.02 RELATED SECTIONS

A. This section contains specific references to the following related sections. Additional related sections may apply that are not specifically listed below.
   1. Section 01 78 23 – Operation and Maintenance Data
   2. Section 40 05 02 – Detailed Piping Specification Sheets
   3. Section 40 06 20.13 – Actuated Valve and Gate Schedules

1.03 REFERENCES

A. This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.

B. Unless otherwise specified, references to documents shall mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid (or on the effective date of the Agreement if there were no Bids). If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued. Where document dates are given in the following listing, references to those documents shall mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, discontinued or replaced.

Reference	Title
ANSI 16.10	Face-to-Face and End-to-End Dimensions of Valves
ANSI B1.20.1	Pipe Threads, General Purpose
ANSI B16.1	Cast Iron Pipe Flanges and Flanged Fittings Class 25, 125, and 250
ANSI B16.5	Pipe Flanges and Flanged Fittings
ANSI B16.34	Valves—Flanged, Threaded, and Welding End
API 607	Fire Test for Quarter-turn Valves and Valves Equipped with Nonmetallic Seats
ASTM A48	Gray Iron Castings
ASTM A108	Steel Bars, Carbon, Cold-Finished, Standard Quality
ASTM A126	Gray Iron Castings for Valves, Flanges, and Pipe Fittings
ASTM A216/A216M	Steel Castings, Carbon, Suitable for Fusion Welding, for High Temperature Service
ASTM A276	Stainless and Heat Resisting Steel Bars and Shapes
ASTM A351	Castings, Austenitic, for Pressure-Containing Parts
ASTM A516	Pressure Vessel Plates, Carbon Steel, for Moderate- and Lower-Temperature Service
ASTM A536	Ductile Iron Castings
ASTM A571	Austenitic Ductile Iron Castings
ASTM A995/A995M-13	Castings, Austenitic-Ferritic (Duplex) Stainless Steel, for Pressure-Containing Parts
ASTM B124	Copper and Copper Alloy Forging Rod, Bar, and Shapes
ASTM B148	Aluminum-Bronze Sand Castings
ASTM C283	Resistance of Porcelain Enameled Utensils to Boiling Acid
ASTM D1784	Rigid Poly (Vinyl Chloride) (PVC) Compounds and Chlorinated Poly(Vinyl Chloride) (CPVC) Compounds
ASTM D5162	Discontinuity (Holiday) Testing of Nonconductive Protective Coating on Metallic Substrates
AWWA C500	Metal-Seated Gate Valves for Water Supply Service
AWWA C504	Rubber-Seated Butterfly Valves
AWWA C507	Standard for Ball Valves
AWWA C508	Swing Check Valves for Waterworks Service, 2 – 24 Inches NPS
AWWA C517	Resilient-Seated Cast Iron Eccentric Plug Valves
AWWA C550	Protective Interior Coatings for Valves and Hydrants
MSS SP-70	Gray Iron Gate Valves, Flanged and Threaded Ends
MSS SP-80	Bronze Gate, Globe, Angle and Check Valves
MSS SP-81	Stainless Steel, Bonnetless, Flanged, Knife Gate Valves

Reference	Title
MSS SP-110	Ball Valves Threaded, Socket-Welding, Solder Joint, Grooved and Flared Ends
NSF 61	Drinking Water System Components - Health Effects
UL 429	Electrically Operated Valves
UL 1002	Electrically Operated Valves for Use in Hazardous Locations, Class I, Groups A, B, C, and D, and Class II, Groups E, F, and G

1.04 SUBMITTALS

A. Action Submittals:
   1. Procedures: Section 01 33 00
   2. A copy of this Section, addendum updates included, with each paragraph check-marked to indicate compliance or marked to indicate requested deviations from specification requirements. Check-marks (✓) denote full compliance with a paragraph as a whole. Underline deviations and denote with a number in the margin to the right of the identified paragraph. The remaining portions of the paragraph not underlined signify compliance on the part of the Contractor with the specifications. Include a detailed, written justification for each deviation. Failure to include a copy of the marked-up specification sections, along with justification(s) for any requested deviations to the specification requirements, with the submittal will be sufficient cause for rejection of the entire submittal with no further consideration.
   3. Catalog cuts and/or shop drawings for each type of valve indicating the valve type (Detailed Valve Specification Section Number), materials of construction, dimensions, operating torque, valve end connection configuration, pressure rating, and operating temperature range.
   4. An amended Detailed Valve Specification for all valve types provided for this contract. Indicate with check marks where the valve supplied meets the requirements specified and with written amendments where the product differs from the specification.
   5. Factory Acceptance Test results and/or Certified Statement of Proof-of-Design testing results when specified in Detailed Valve Specifications.
   6. Action Submittal Items listed on Detailed Valve Specifications

B. Informational Submittals:
   1. Affidavits and registration numbers as specified.
   2. Operating and Maintenance data for incorporation in operation and maintenance manual, as specified in Section 01 78 23. Include complete description of operation together with detailed drawings, a complete list of replacement and repair parts, and parts manufacturer's identifying numbers.
   3. Informational Submittal Items listed on Detailed Valve Specifications.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Procedures: Section 01 66 00.

B. Deliver valves to site in accordance with Section 01 66 00 and using loading methods which do not damage any valve components or coatings.

C. Tag loose valves as specified in Section 01 66 00, stating size, type, coatings and mating parts shipped loose or separate.

D. Store on site until ready for incorporation in the work using methods recommended by the manufacturer to prevent damage, undue stresses, or weathering.

1.06 WARRANTY

A. Procedures: Section 01 78 36-Warranties.

B. Where a warranty duration is specified by the Detailed Valve Specification, provide a special warranty valid for the specified duration.

C. Where no special warranty requirements are specified in the Detailed Valve Specification, provide manufacturer's standard warranty.

PART 2 PRODUCTS

2.01 VALVE CONFIGURATION REQUIREMENTS

A. General
   1. Provide valves of the same type, size range and service from a single manufacturer.
   2. Provide new, unused valves for the work.
   3. Provide valve materials free from defects or flaws, with true alignment and bores.
   4. Provide valves that open by turning the valve shaft to rotate counter-clockwise unless otherwise specified in the Detailed Valve Specification Section.

B. Provide padlockable lockout feature on all valves.

C. Manual Operators
   1. Provide valves with manual operators as specified in the Detailed Valve Specification, unless specified otherwise in Section 40 06 20.13.
   2. For hand wheels, clearly show the direction of opening in raised lettering and symbols.
   3. The maximum rim pull on a hand wheel is not to exceed 65 lb. when one side of the valve is at test pressure and the other side is at atmospheric pressure. Where a shaft mounted hand wheel would require greater force to operate, provide a torque reduction gearbox operator. Unless different operators are scheduled or specified on the Drawings, conform to the following minimum requirements.
   4. Provide 6 (total) eight-point operating wrenches for use on all valves with square nut operators.
   5. Quarter turn lever operators are to be perpendicular to the pipe runs when the valves are closed.
   6. Provide butterfly valves with 10 position latching levers except where used to balance air flows. Where used to balance air flows provide infinite position, screw down levers.

7. The maximum pull at the end of the lever arm is not to exceed 65 lb. when one side of the valve is at test pressure and other side is at atmospheric pressure. Where greater force would be required to operate the valve with a lever, provide a torque reduction gearbox operator.
8. Provide grease lubricated, worm gear type operators for torque reduction gearbox operators. Gearbox operators equipped with a hand wheel and a visual indicator of the valve position. Provide gear operators with adjustable mechanical stop-limiting devices to prevent over travel of the disc/ball/plug in the open and closed positions and which are self-locking and designed to hold the valve in any intermediate position between full open and full closed. Where gearbox operators are intended for direct bury or submergence, seal units with long life lubricant.
9. For manual valves on lines 3 inches and greater, mounted over 7.0 feet above the operating floor, provide chain wheel gear operators. Design chain wheel operators so that a force of 30 lb. is sufficient to open the valve when one side of the valve is at test pressure and the other side is at atmospheric pressure. Provide chain pulley that positively engages the chain links. The chain will extend from the valve operator to an operating height of 4 feet above the floor or as directed by the Owner. The exact dimensions will be field determined. Provide approved chain hooks where required to prevent chain from hanging within traffic paths.
10. Where manual operators are installed over 7.0 feet above the operating floor and the Drawings specify a vertical valve shaft, revise the gear operator and/or chain wheel position to provide a horizontal chain wheel shaft. Retain the valve orientation specified on the Drawings.
11. Provide ductile iron chain wheels. Provide galvanized steel operating chains.

D. Valve Stem Extensions and Wrench Nuts
   1. Provide valve stem extensions where additional clearance is required for pipe insulation or where valve operation without the extension is difficult; and in manholes.
   2. Where angle valve stem extensions are employed, they will be angle geared. Universal joint types are not permitted.
   3. Wrench nuts shall comply with AWWA C500. A minimum of two operating keys, but no less than one key per every ten valves, shall be provided for operation of wrench nut operated valves.

E. Operator Appurtenances
   1. Valve Boxes: Valve boxes shall be cast iron and shall have suitable base castings to fit properly over the bonnets of their respective valves and heavy top sections with stay-put covers. Covers shall be hot-dip galvanized. Valve boxes extending to finished surfaces shall be provided for buried valves.
   2. Floor Boxes: Floor boxes shall be hot-dip galvanized. Where the operating nut is in the concrete slab, the floor box shall be bronze bushed. Where the operating nut is below slab, the opening in the bottom of the box shall be sufficient for passage of the operating key. Floor boxes shall be provided for wrench operation of valves located below concrete slabs. Each floor box and cover shall be of the depth required for installation in the slab.

3. Adjustable Shaft Valve Boxes: Adjustable shaft valve boxes shall be concrete or cast iron Brooks No. 3RT, Christie G5, Empire 7-1/2 valve extension box, or equal. Box covers on water lines shall be impressed with the letter "W." Gas line covers shall be impressed with the letter "G."

2.02 VALVE IDENTIFICATION TAGS

A. Provide valve identification tags for all valves with an identification tag number on the drawings (Mechanical and PI&D drawings).

B. Match tag numbers shown on the drawings.

C. Type 316 stainless steel tags, minimum 2.5-inches x 0.75 inches, with 0.1875 inch numbers and letters. Complete tag number shall be embossed on the tag. Tags shall be attached using stainless steel wire.

PART 3 EXECUTION

3.01 PREPARATION

A. The valve and piping arrangement indicated on the Drawings is based on typical dimensions for valves of the specified type. Make the necessary modifications in the piping to allow for discrepancies between the valve dimensions shown and those supplied for the Work.

B. Prior to installation of valves, field measure and check all equipment locations, pipe alignments, and structural installations. Ensure that the valve location and orientation provides suitable access to manual operators and that sufficient space and accessibility is available for hydraulic, pneumatic, and electric power actuators.

C. Where conflicts are identified, inform the Owner.

3.02 INSTALLATION

A. Install valves in conjunction with the piping specified in the Piping System Schedules (Sections 40 05 02.01 through 40 05 02.99), and with control valves and their appurtenances specified in Section 40 06 20.13.

B. In horizontal pipe runs, other than in locations where space does not permit, install all valves (except for butterfly valves, eccentric plug valves, and trunnion ball valves) with a vertical operating shaft with the actuator at the top. In no case install a valve with the operator below the valve.

C. Unless otherwise specified on the drawings, install butterfly valves, eccentric plug valves, and trunnion ball valves with the shaft in a horizontal orientation. Install eccentric plug valves with the plug above the valve shaft centreline when the valve is full open.

D. When joining valves to pipe or fittings, do not over torque bolts to correct for misalignment.

E. Support valves in position using temporary supports until valves are fixed in place.

F. Permanently support valves to prevent transmission of loads to adjacent pipework and/or equipment.

G. Where valves are installed in plastic pipelines (PVC, CPVC, HDPE, polypropylene etc.) greater than 4-inch diameter, support valves independent of the piping and brace valves against operating loads and torque to prevent transmission of stresses to the adjacent pipework.

H. Install gate valves in the closed position.

I. Install valves which are bubble tight in one direction to provide bubble tight seal of flow in normal direction of flow unless otherwise noted or directed by the Owner.

J. Unless otherwise specified, install single seated valves with the seat downstream. Install valves at tank connections with seat away from tank. Install valves on pump discharge and suction lines with seat end towards the pump.

K. Install all valves in accordance with the manufacturer's recommendations.

L. Protect valves installed below grade with a shrink sleeve or polyethylene sheath attached to the pipe with tape wrap.

M. Wrench nuts shall be provided on buried valves, on valves which are to be operated through floor boxes, and where specified. Extended wrench nuts shall be provided if necessary so that the nut will be within 6 inches of the valve box cover.

3.03 FIELD QUALITY CONTROL

A. Field or Site Tests and Inspections per Detailed Valve Specifications.

B. Pressure test all valves in conjunction with the pipes in which the valves are installed at test pressures specified in the applicable Piping System Schedule.

END OF SECTION

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40 05 62.01

PLUG VALVE, AWWA C517 STANDARD PORT

GENERAL

1. Line Size: 3 through 12 inches
2. Rated Limits: Pressure 175 psi; Temperature 125 °F
1. Line Size: 14 through 72 inches
2. Rated Limits: Pressure 150 psi; Temperature 125 °F

VALVE MATERIALS

1. Body: Cast Iron
2. Plug: Cast Iron or Ductile Iron
3. Plug Facing: Neoprene or Buna-N
4. Seatings: Ni or Stainless Steel
5. Packing: Buna V-flex or TFE
6. Bearings: Stainless Steel
7. Grit Excluder: PTFE or Buna-N

VALVE CONFIGURATION

1. Valve End/Connections: ANSI B16.1 Class 125# Flange
2. Pattern: One-piece, Standard Port; provide 100% minimum port area of adjacent pipe for valves 4 inches and less, provide 80 to 85% port area of adjacent pipe for valves 6 to 24 inches, provide 75% minimum port area of adjacent pipe for valves 30 inches and larger
3. Reference Standard: AWWA C517
4. Installation: install with shaft in horizontal position, valve seat located upstream
5. Operator: Handwheel
6. Special: upper and lower journal bearings shall be replaceable, sleeve-type, corrosion resistant, and permanently lubricated; packing shall be self-adjusting chevron type replaceable without disassembling the valve

SUBMITTALS

1. Comply with Section 01 33 00 – Submittal Procedures.
2. Provide submittal information specified in Section 40 05 60 – Valves.
3. In addition to submittals specified in Section 40 05 60 – Valves, provide the following:

   Action Submittals:

   a. Furnish three certified copies of a report from an independent testing laboratory certifying successful completion of proof-of-design testing conducted in accordance with AWWA C517, Section 5.2. In lieu of testing the valves at an independent testing laboratory, proof-of-design testing may be performed at the valve manufacturer's laboratory, but must be witnessed by a representative of a qualified independent testing laboratory, and all test reports must be certified by the laboratory representative. Proof-of-design testing shall have been performed on not less than three 6-inch diameter valves, with all three test units demonstrating full compliance with the test standards. Failure to satisfactorily complete the test shall be deemed sufficient evidence to reject all valves of the proposed make or manufacturer's model number.

CANDIDATE MANUFACTURERS
1. Val-Matic Cam Centric 2. DeZurik PEC

END OF SECTION

40 05 63.02

BALL VALVE, BRONZE/BRASS, FULL PORT

GENERAL

1. Line Size: ¼ through 2 ½ inches
2. Rated Limits: Pressure 600 psi; Temperature 400 °F (CWP)

VALVE MATERIALS

1. Body: Bronze or Brass
2. Ball: Bronze or Chrome-Plated Brass
3. Seats: PTFE or RPTFE
4. Shafts: Bronze, Brass, or Stainless Steel; blowout-proof stem

VALVE CONFIGURATION

1. Valve End/Connections: Threaded, Female; provide threaded end cap and chain in drain pipes
2. Pattern: 2 Piece; regular port
3. Ball Mount: Floating
4. Manual Operator: Lever
5. Reference Standard: MSS SP-110

SUBMITTALS

1. Comply with Section 01 33 00 – Submittal Procedures.
2. Provide submittal information specified in Section 40 05 60 – Valves.
3. In addition to submittals specified in Section 40 05 60 – Valves, provide the following:
   Action Submittals:
   a. Manufacturer's standard product data

CANDIDATE MANUFACTURERS

1. Stockham T-285-BR-R
2. Nibco T-585-70
3. Apollo 70-100 Series

END OF SECTION

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40 05 63.06

BALL VALVE, CPVC

GENERAL
1. Line Size: ½ through 4 inches 2. Rated Limits: Pressure 130 psi; Temperature 140 °F
VALVE MATERIALS
1. Body: CPVC; ASTM D1784 (Grade A) 2. Ball: CPVC; ASTM D1784 (Grade A) 3. O-Rings: EPDM or FKM 4. Seats: PTFE 5. Shafts: CPVC; ASTM D1784 (Grade A), blowout-proof ball and stem
VALVE CONFIGURATION
1. Valve End/Connections: Threaded, Female, True Union; ASTM D2464 2. Pattern: Full Port; bi-directional 3. Ball Mount: Floating 4. Manual Operator: Lever
SUBMITTALS
1. Comply with Section 01 33 00 – Submittal Procedures. 2. Provide submittal information specified in Section 40 05 60 – Valves.
CANDIDATE MANUFACTURERS
1. IPEX VXE/VKD

END OF SECTION

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40 05 63.09

BALL VALVE, STEEL

GENERAL
1. Line Size: ½ through 12 inches 2. Rated Limits: Pressure 250 psi; Temperature 150 °F
VALVE MATERIALS
1. Body: Steel 2. Ball: Stainless Steel (304 or 316) 3. Seats: PTFE 4. Packing: RPTFE 5. Stem: Stainless Steel (304 or 316); blowout-proof stem
VALVE CONFIGURATION
1. Valve End/Connections: Flange, ANSI B16.1 Class 150# 2. Pattern: Full Port 3. Ball Mount: provide trunnion-mounted ball on all valves sizes 10 inches and greater, provide floating ball on all valves sizes 8 inches and smaller 4. Manual Operator: Lever/Handwheel; provide lever operators for valves 4 inches and less, provide geared operators for valves 6 inches and greater
SUBMITTALS
1. Comply with Section 01 33 00 – Submittal Procedures. 2. Provide submittal information specified in Section 40 05 60 – Valves.
CANDIDATE MANUFACTURERS
1. Kitz 150SCTDZM 2. Bray Flow-Tek F15 3. Metso Jamesbury 9150

END OF SECTION

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40 05 64.91

BUTTERFLY DAMPER, FRP

GENERAL

1. Line Size: 4 through 72 inches
2. Rated Limits: Pressure 1 psi; Temperature 200 °F

VALVE MATERIALS

1. Body: FRP; premium, corrosion resistant, flame retardant, vinyl ester resin: Derakane 510A or Hetron FR992, minimum 3mm corrosion barrier, FRP construction per ASTM D3982 and ASME/ANSI RTP-1, paraffinated gel coat with ultraviolet inhibitor
2. Blade: FRP; premium, corrosion resistant, flame retardant, vinyl ester resin: Derakane 510A or Hetron FR992, minimum 3mm corrosion barrier, FRP construction per ASTM D3982 and ASME/ANSI RTP-1, L/360 blade deflection, provide stiffeners as required, 316 stainless steel for any metal used in stiffener construction
3. Shaft: FRP or FRP-encapsulated 316 Stainless Steel; extend shaft full length of blade and 150 mm beyond frame, mount damper with shaft in horizontal plane
4. Shaft Seal: FRP with Viton O-ring
5. Bearings: PTFE

VALVE CONFIGURATION

1. Valve End/Connections: Flange; flange per ASTM D3982, flange and corrosion barrier to be integral to body
2. Manual Operator: Lever/Handwheel; diameter $\leq$ 20 inches crank levers with infinite screw down positioners (316 stainless steel for all metal components), diameter > 20 inches worm gear operator (316 stainless steel for metal components in contact with process fluid)

SUBMITTALS

1. Comply with Section 01 33 00 – Submittal Procedures.
2. Provide submittal information specified in Section 40 05 60 – Valves.
3. In addition to submittals specified in Section 40 05 60 – Valves, provide the following:

   Action Submittals:

   a. Provide AMCA certification.

CANDIDATE MANUFACTURERS

1. Swartwout Model 914
2. Belco Model 203
3. Daniel Mechanical DanELAST 303

END OF SECTION

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40 05 65.01

CHECK VALVE, BRONZE SWING

GENERAL
1. Line Size: ¼ through 3 inches 2. Rated Limits: Pressure 240 psi; Temperature 275 °F
VALVE MATERIALS
1. Body: Bronze 2. Disc: Brass or Bronze 3. Seats: Bronze 4. Hinge Pin: Stainless Steel or Copper
VALVE CONFIGURATION
1. Valve End/Connections: Threaded, Female 2. Check Mechanism: Swing Check, T or Y Pattern; regular port 3. Reference Standard: MSS SP-80 Type 3
SUBMITTALS
1. Comply with Section 01 33 00 – Submittal Procedures. 2. Provide submittal information specified in Section 40 05 60 – Valves.
CANDIDATE MANUFACTURERS
1. Hattersley Figure 47 2. Crane Figure 37/137 3. Kitz No. 29

END OF SECTION

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40 05 65.02

LIFT CHECK, BRONZE

GENERAL
1. Line Size: ¼ through 2 inches 2. Rated Limits: Pressure 240 psi; Temperature 275 °F
VALVE MATERIALS
1. Body: Bronze 2. Disc: PTFE 3. Disc Holder: Bronze
VALVE CONFIGURATION
1. Valve End/Connections: Threaded, Female 2. Check Mechanism: Lift Check 3. Reference Standard: MSS SP-80 Type 2
SUBMITTALS
1. Comply with Section 01 33 00 – Submittal Procedures. 2. Provide submittal information specified in Section 40 05 60 – Valves.
CANDIDATE MANUFACTURERS
1. Crane 27TF

END OF SECTION

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40 05 65.05

CHECK VALVE, CPVC BALL TYPE

GENERAL
1. Line Size: ½ through 4 inches 2. Rated Limits: Pressure 150 psi; Temperature 80 °F
VALVE MATERIALS
1. Body: CPVC; schedule 80 2. Ball: CPVC 3. Seats, Gasket: EPDM or FKM 4. Hinge Pin, Swing Arm: CPVC 5. Fasteners: Stainless Steel (304)
VALVE CONFIGURATION
1. Valve End/Connections: Flange, ANSI Class 150 2. Type: Ball Check, Single Union 3. Pattern: Full Port
SUBMITTALS
1. Comply with Section 01 33 00 – Submittal Procedures. 2. Provide submittal information specified in Section 40 05 60 – Valves.
CANDIDATE MANUFACTURERS
1. Chemtrol True Union Ball Check 2. Chemline BT Series 3. Hayward TC Series

END OF SECTION

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40 05 65.16

CHECK VALVE, LEVER ARM AND SPRING, TRANSIENT SERVICE, 150 psi

GENERAL

1. Line Size: 2 through 12 inches
2. Rated Limits: Pressure 175 psi; Temperature 100 °F
1. Line Size: 14 through 66 inches
2. Rated Limits: Pressure 150 psi; Temperature 100 °F

VALVE MATERIALS

1. Body: Cast Iron, ASTM A126, Grade B or Ductile Iron, ASTM A536; body permits mounting external lever and springs on either side of the valve, clear opening size equal to or greater than connecting pipe
2. Disc: Ductile Iron, ASTM A536; pivot arm secured to disc with twin bolted connections or a pinned nut, disc and lever arm keyed to the shaft and retained by bushings or pins
3. Body Seat: Aluminum Bronze or Stainless Steel
4. Disc Seal: Nitrile (Buna-N/BR)
5. Hinge Pin/Shaft: Stainless Steel; provided with stuffing box and packing or O-ring seal at each shaft penetration through valve body, minimum shaft diameters as follows:

Valve Inlet Size, Inches	3	4	6	8	10	12	14	16	18
Shaft Diameter Inches	0.75	0.825	1.00	1.75	2.00	2.50	2.75	3.25	3.5

Valve Inlet Size, Inches	20	24	30	36	42	48	54	60	66
Shaft Diameter Inches	3.75	3.75	3.75	4.00	4.75	5.25	5.50	5.75	6.00

6. Shaft Bushings: Bronze

VALVE CONFIGURATION

1. Valve End/Connections: Flanged, ASME B16.1 Class 125
2. Check Mechanism: Swing
3. Closure Control: Lever Arm and Spring; capable of closing within 0.05 seconds of pump stoppage with fluid moving at 8 feet/second, adjustable spring tension
4. Lining: Epoxy, 12 mils

SUBMITTALS

1. Comply with Section 01 33 00 – Submittal Procedures.
2. Provide submittal information specified in Section 40 05 60 – Valves.

CANDIDATE MANUFACTURERS

1. Golden Anderson Series 220
2. DeZurik/Apco Series 6000

END OF SECTION

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SECTION 40 06 20.13

POWER ACTUATED VALVE AND GATE SCHEDULE FOR PROCESS SERVICES

PART 1 GENERAL

1.01 DESCRIPTION

A. This section specifies requirements for actuators for valves and gates that are positioned or controlled by means other than manual actuation. For the purposes of this Section, actuated valves and gates include valves and/or gates that are operated and/or controlled using hydraulic, pneumatic, or electric power.

1.02 RELATED SECTIONS

A. Section 40 05 02 – Piping Systems Schedules

B. Section 40 05 60 – Valves

C. Section 43 05 11 – General Requirements for Equipment

1.03 REFERENCES

A. This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section prevail.

Reference	Title
ISA-S75.02	Standard Control Valve Capacity Test Procedure

1.04 ADMINISTRATIVE REQUIREMENTS

A. Unit Responsibility:
   1. Assign Unit Responsibility, as specified in Section 43 05 11, to the actuator manufacturer. The actuator manufacturer has Unit Responsibility, as defined in Section 43 05 11, for each valve or gate and the associated actuator. Assemble the valve/gate and actuator at the factory for shipment to the project site.

1.05 SUBMITTALS

A. Action Submittals:
   1. Procedures: Section 01 33 00
   2. Valve Specifications for all valve types (Valve Specifications in Sections 40 05 60 through 40 05 90). Indicate with check marks where the valve supplied meets the requirements specified and with written amendments where the product differs from the specification.

3. Catalog cuts and/or shop drawings for each valve type listed in the Actuated Valve and Gate Schedule. For each valve type (Valve Specification in Sections 40 05 60 through 40 05 90) indicate materials of construction, dimensions, operating torque, fail position, valve end connection configuration, pressure rating, and operating temperature range.
4. Open/Close time. Where open/close times are specified in the Actuated Valve and Gate Schedule, submit information documenting valve operating speed. Include information on motor operating speed, gear ratio, exhaust port flow restriction, or other means of speed control.
5. For each solenoid valve type and size combination, submit manufacturer's literature listing enclosure type, solenoid valve model number/type, maximum differential operating pressure, and minimum operating pressure.
6. List actuator type for each equipment number listed in the Actuated Valve and Gate Schedule.
7. Submittal information listed in actuator specification.
8. Certificate of Unit Responsibility attesting that the Contractor has assigned unit responsibility in accordance with the requirements of this section and Section 43 05 11.

B. Closeout Submittals:
1. Procedures: Section 01 78 23.
2. Operating and maintenance submittals per Section 01 78 23.

1.06 ACTUATED VALVE AND GATE SCHEDULE

A. Furnish valves and gates conforming to the requirements specified in the Actuated Valve and Gate Schedule

B. Equipment Tag:
1. Refer to Section 01 08 00 for identification requirements.
2. The Equipment Tag for the valve is constructed as follows (e.g., 72CON4201):
   a. 72 – Project Area (Solids Processing Center)
   b. CON – Equipment abbreviation (Conveyor).
   c. 4201 – Process Identifier (4201)

C. Valve / Gate Type:
1. The Gate/Valve Type column identifies a Valve Specification or Gate Specification for each Valve/Gate and Actuator combination.
2. Refer to the listed specification for the required valve or gate characteristics (i.e. valve/gate materials, dimensions, and configuration).

D. Powered actuator types are specified in Section 40 05 57.23. Actuator types used in the valve and gate schedule are defined as follows:

Actuator Type (ACTUSPEC)	Service	Definition
EMTI	Isolating (Open-Close)	Electric motor multi-turn
SOL	Isolating (Open-Close)	Solenoid

E. Actuator Enclosure, NEMA Type: Enclosure requirements for actuators are specified by NEMA enclosure type.

F. Maximum Pressure Differential: Pressure drop across each valve is specified for the purpose of actuator and gear box sizing. If no value is specified in this column, use the test pressure from the specified Piping System Schedule (Section 40 05 02.00 through 40 05 02.99) as the maximum pressure differential. Seating and unseating head requirements for gates are specified in the gate specification and are not included in this Section.

G. Open/Close Time: The open/close time refers to the time required for the valve to travel from full closed to full open. Open/close times are based on continuous operation of the actuator. Entries in this column are minimum values. Configure the actuator to provide an open/close time greater than the value listed in this column. Actuators that include programmed stops or steps are not acceptable.

H. Fail Position: Fail position indicates the position that the actuator will default to upon loss of electric, pneumatic, or hydraulic power supply for control of the actuator:
   1. Closed. (Fail Closed) Configure actuator to close upon loss of electric, pneumatic, or hydraulic power supply for control of the valve or gate.
   2. Open. (Fail Open) Configure actuator to open upon loss of electric, pneumatic, or hydraulic power supply for control of the valve or gate.
   3. Last. (Fail Last Position) Configure actuator to remain in the position last held by the actuator prior to loss of electric, pneumatic, or hydraulic power supply for control of the valve or gate.

I. Voltage: This column specifies the supply power voltage and number of phases for the power supply to solenoids, electric motor actuators, and electro-hydraulic actuators. Provide actuators for operation with the specified power supply voltage and phase.

J. Maximum Power Demand: This column specifies the maximum amperage rating for the electric power supply to the actuator. Provide actuators with electric power requirements that do not exceed the specified amperage rating listed in this column.

K. DeviceNet Communication: This column specifies which actuators are to be furnished with DeviceNet network communication capabilities. If a check mark (✓) appears in the schedule, furnish the associated actuator with DeviceNet communications capabilities as specified in the actuator specification.

L. Remote Control Station: This column specifies which actuators are to be furnished with a Remote Control Station. If a check mark (✓) appears in the schedule, furnish the associated actuator with a remote control station, configured as specified on the Drawings.

PART 2 NOT USED

PART 3 NOT USED

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PART 4 SCHEDULE

4.01 ACTUATED VALVE AND GATE SCHEDULE

Equipment Number	Valve/Gate Specification	Actuator Type	Actuator Enclosure, NEMA Type	Maximum Differential Pressure (psi)	Open/Close Time (seconds)	Fail Position	Voltage (Voltage / Phase)	Area Classification	Remote Control Station	Notes
72G4301	41 12 13.16	EMTI	4X	5	60	LAST	480/3	UNCLASSIFIED	YES	1, 2
SOLENOID VALVE - VARIES	46 76 27	SOL	-	-	-	CLOSED	120/1	UNCLASSIFIED	YES	1, 3

Notes:

1. *Provide as intended by the Engineer, not necessarily as specified herein, and to the satisfaction of the Owner.*
2. *Provided with shafted screw conveyor system as specified in Section 41 12 13.16.*
3. *Solenoid valves provided by screw press manufacturer. Quantity solenoid valves and operation shall be determined by the screw press manufacturer.*

END OF SECTION

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SECTION 40 42 00

INSULATION FOR EXPOSED PIPING AND EQUIPMENT

PART 1 GENERAL

1.01 SUMMARY

A. Section includes thermal insulation for exposed piping, related equipment, and appurtenant surfaces.

1.02 RELATED SECTIONS

A. Section 40 05 02 – Detailed Piping Specification Sheets

B. Section 40 50 07 – Pipe Supports and Hangers

C. Section 40 05 07.13 – Seismic Restraints for Piping

D. Section 40 05 45 – Piping System Identification

1.03 REFERENCES

A. This Section incorporates by reference the following documents. They are part of this Section insofar as specified and modified herein. In the event of conflict between the requirements of this Section and those of a listed document, the requirements of this Section prevail.

B. ASTM B209 – Aluminum and Aluminum-Alloy Sheet and Plate

C. ASTM C533 – Calcium Silicate Block and Pipe Thermal Insulation

D. ASTM C534 – Preformed Flexible Elastomeric Cellular Thermal Insulation in Sheet and Tubular Form

E. ASTM C547 – Standard Specification for Mineral Fiber Pipe Insulation

F. ASTM C553 – Mineral Fiber Blanket Thermal Insulation for Commercial and Industrial Applications

G. ASTM C592 – Mineral Fiber Blanket Insulation and Blanket-Type Pipe Insulation

H. ASTM C610 – Expanded Perlite Block and Pipe Thermal Insulation

I. ASTM C795 – Thermal Insulation for Use in Contact with Austenitic Stainless Steel

J. ASTM E84 – Standard Test Method for Surface Burning Characteristics of Building Materials

K. ASTM E96 – Water Vapor Transmission of Materials

L. FEDSPEC L-P-535E -- Plastic Sheet (Sheeting) “Plastic Strip” Poly (Vinyl Chloride) and Poly (Vinyl Chloride-Vinyl Acetate), Rigid

M. ASTM C1676 – Microporous Thermal Insulation

N. ASTM C1729 – Aluminum Jacketing and Insulation

1.04 DEFINITIONS

A. Terminology used in this Section conforms to the following definitions:

B. Low-temperature range: operating temperature range of -100 to +100 degrees F.

C. Medium-temperature range: operating temperature range of 100 to 800 degrees F.

D. High-temperature range: operating temperature range of 800 to 1200 degrees F.

E. Very-high-temperature range: operating temperature range of 1200 to 1800 degrees F.

F. Jacket: protective outer layer placed over insulation on straight runs of pipe

G. Cover: protective outer layer placed over insulation on valves, strainers, expansion joints, flanges, pipe fittings, couplings, and equipment.

H. Exposed: All area exposures specified in Section 01 61 45 other than buried, submerged, or encased/embedded.

1.05 ADMINISTRATIVE REQUIREMENTS

A. Sequencing: After installation of insulation for pipe and equipment is complete, provide identification as described in Section 40 05 45.

1.06 SUBMITTALS

A. Procedures: Section 01 33 00

B. Action Submittals:
   1. A copy of this Section, addendum updates included, with each paragraph check-marked to indicate compliance or marked to indicate requested deviations.
   2. Manufacturer's descriptive literature, including insulation and jacket thickness, heat transfer coefficient, and methods of installation.
   3. Certification of jacket ratings for water vapor transmission, puncture and stiffness as specified.
   4. ASTM C795 certification, for insulation applied to stainless steel pipe.

C. Informational Submittals:
   1. Samples of each insulation material type and thickness along with typical jackets and covers for pipe, fittings, valves and appurtenances. Provide a full diameter segment for each insulation sample, 6 inches in length.

D. Closeout Submittals:
   1. Warranty Documentation

1.07 DELIVERY, STORAGE, AND HANDLING

A. Procedures: Section 01 66 00

B. Deliver insulation, jackets and covering to site using methods which do not damage the materials.

C. Deliver insulation materials to site clearly identified as to type and temperature rating.

D. Store insulation materials on site as recommended by the manufacturer to prevent damage or weathering.

E. Replace damaged or weathered insulation materials with new materials.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Manufacturers: Candidate manufacturers and models are listed below. The manufacturer's standard product may require modification to conform to specified requirements.

B. Cellular Elastomeric Tube
   1. Armacell, AP Armaflex
   2. K-Flex, Insul-Tube
   3. Approved Equal

C. Mineral Wool
   1. Roxul, ProRox PS960
   2. Johns Manville, Min-Wool 1200
   3. Owens Corning, Thermafiber Pro Section WR
   4. Approved Equal

D. Fiberglass
   1. Johns Manville, Micro-Lok HP
   2. Owens Corning, FIBERGLAS
   3. Approved Equal

E. Calcium Silicate
   1. Johns Manville, Thermo-1200
   2. Approved Equal

F. Cellular Elastomeric Flexible Blanket
   1. Armacell, AP Armaflex
   2. K-flex, Insul-Sheet
   3. Approved Equal

G. Fiberglass Flexible Blanket
   1. Amatex, Amamat
   2. Lewco, E Glass
   3. Approved Equal

H. Mineral Wool Flexible Blanket
   1. Johns Manville, Min-Wool 1200 Pipe and Tank Wrap
   2. Roxul, Enerwrap MA 960
   3. Approved Equal

I. Silica or Ceramic Fiber Flexible Blanket (Very High Temperature Range)
   1. Morgan Thermal Ceramics, Superwool 607 Blanket AC2
   2. Unifrax, Fiberfrax
   3. Harbison Walker, Inswool-HP
   4. Hitco, Refrasil
   5. Approved Equal

J. Expanded Perlite
   1. Johns Manville, Sproule WR-1200
   2. Approved Equal

K. Thin Flexible Blanket
   1. Johns Manville, InsulThin HT
   2. Approved Equal

2.02 INSULATION SERVICE CONDITIONS

A. Insulation Service Types
   1. Insulation service types define the function of the insulation. The extent and location of insulation application is based on the function of the insulation. This Section specifies the following insulation service types: Condensate Control, Personnel Protection, Freeze Protection, and Energy Conservation. Insulation Service Types and insulation materials for piping systems are specified in Piping System Schedules.
   2. Condensate Control is specified for piping that is to be insulated for condensate control. Where Condensate Control is specified for a piping service, furnish insulation for all pipe and pipeline appurtenances with a line size of ½-inch and larger that are located in Indoor Dry or Indoor Wet areas.
   3. Personnel Protection is specified for piping that is to be insulated to protect personnel from injury related to exposure to temperatures above 140 degrees F or below 32 degrees F. Where Personnel Protection is specified for a piping service in the Piping System Schedules, furnish insulation for all pipe and pipeline appurtenances where all of the following conditions are present:
      a. Piping is connected to the discharge or exhaust of equipment (includes equipment and pipeline appurtenances).

b. Equipment, pipe, or pipeline appurtenances are located within 0.0 to 8.0 feet above a floor, stair, landing, or other type of walkway accessible by plant staff, or within 4.0 feet of a guardrail or ladder cage. Pipe, pipeline appurtenances, joints, flanges, valves, and equipment in vaults, utilidors, and other spaces that are not designed for pedestrian access by plant staff are not insulated for Personnel Protection.

4. Freeze Protection is specified for piping that is to be insulated to protect against freezing the contents of the pipe.
5. Energy Conservation is specified for piping that is to be insulated to conserve energy. Where Energy Conservation is specified for a piping service in the Piping System Schedules, furnish insulation for all pipe and pipeline appurtenances for the entire portion of the piping system that is exposed.

2.03 MATERIALS

A. General:
   1. Provide materials that are new and undamaged.
   2. Match specified pipe insulation and jacket/cover material for insulation on valves, strainers, fittings, expansion joints, flanges, and other pipe couplings. Furnish flexible blanket insulation and soft covers if insulation on valves, strainers, fittings, expansion joints, flanges, and other pipe couplings is not available in the same materials as the specified pipe insulation and jacket/cover.
   3. Provide rigid insulation and shields at pipe supports for insulated pipe. Match specified jacket/cover material for pipe shields at pipe supports.
   4. Provide insulating and sealing materials, including cements, coverings, etc., that do not contain asbestos, mercury, or lead.
   5. When covering stainless steel pipe, pipeline appurtenances, or equipment, use insulation that complies with ASTM C795.
   6. Flame spread classification for insulation materials is not to exceed 25 when tested in accordance with ASTM E84.
   7. Use fibrous loose fill insulation for joint filler around insulated expansion joints.

B. Fiberglass Flexible Blanket: Flexible fiberglass blanket insulation designed for continuous 1200-degree F service. 8.0 pounds per cubic foot density, minimum. Long fiber, random orientation, needled.

C. Mineral Wool Flexible Blanket: Flexible mineral wool blanket insulation designed for continuous 1200 degree F service.

D. Silica or Ceramic Fiber Flexible Blanket: High purity alumina and silica non-asbestos white ceramic fiber insulation designed for continuous 1800 degree F service.

E. Aluminum Insulation Jackets/Covers
   1. Aluminum jackets and covers constructed of smooth finish aluminum sheet conforming to ASTM B209, alloy 3003, or 3105 temper H14, with integral vapor barrier.

2. Pipe Insulation Jacket thickness per ASTM C1729, as follows.

Outer Insulation Diameter (inches)	Aluminum jacket thickness, rigid insulation (inch)	Aluminum jacket thickness, flexible and semi-rigid insulation (inch)
≤ 8	0.016	0.016
8 thru 11	0.016	0.020
11 thru 24	0.016	0.024
24 thru 36	0.020	0.032
≥ 36	0.024	0.040

3. Furnish 0.030 inch, minimum thickness, for aluminum insulation covers at valves, strainers, fittings, expansion joints, flanges, and other pipe couplings.
4. Aluminum or stainless steel sheet metal screws.
5. Jackets secured with 0.020 inch thick by ¾ inch wide Type 304 stainless steel expansion bands.
6. Flashing includes aluminum caps, sealant and reinforcing.
7. Provide aluminum caps, 20 gauge. Cut to completely cover the insulation.
8. Provide sealants as recommended by the insulation manufacturer.
9. Provide wire mesh reinforcement or nylon fabric reinforcement in sealant at jacket and cover joints. Reinforcement material as recommended by the insulation manufacturer.

F. PVC Insulation Jackets and Covers
1. One piece PVC covers and jackets. 20 mil thickness, minimum.
2. Pre-molded polyvinylchloride conforming to FEDSPEC L-P-535E, Composition A, Type II, Grade E4.

G. Non-combustible Fabric Cover
1. Custom fit reusable covers. Sewn or stapled covers encapsulating insulation with stainless steel staples/hog rings. Close fit to the piping, pipeline appurtenance, or equipment housing.
2. Fabricated from 32 ounce TFE-coated or silicone coated fiberglass cloth with concealed/interior stitching, staples or hog rings (not exposed). For flexible blanket insulation installed for High-Temperature and Very High-Temperature Range applications, eliminate non-combustible fabric material on hot face of covers and provide stainless steel wire mesh on hot face of covers.
3. Fabric rated for continuous exposure to the temperature range of the insulation (Low, Medium, High, or Very High Temperature Range).
4. Secured in place with stainless steel lacing hooks, lock washers, and lacing wire.
5. Stitched or quilted to prevent consolidation, shifting, or settlement of insulation when subjected to vibration.

PART 3 EXECUTION

3.01 PREPARATION

A. Apply insulation over clean, dry surfaces.

B. Ensure insulation is dry before and during application.

C. Do not apply protective pipe coatings to outside surface of insulation jackets or covers.

D. Do not paint PVC, aluminum, or fabric covers.

E. Do not install insulation or jackets/covers before piping and equipment has been tested and approved. Thermal shields at pipe hangers and supports may be installed prior to testing.

3.02 INSTALLATION

A. General
   1. Where insulation thickness exceeds 3 inches, double layer insulation must be provided. Install double layer insulation with staggered section joints.
   2. Supply insulated thermal pipe hanger shields and install during pipe support installation. Where insulated thermal pipe hanger shields are used, apply the following to all butt joints:
      a. For pipe insulation with a medium, high, or very high Operating Temperature Range, apply 3 inch wide vapor barrier tape or band over the butt joints.
      b. For pipe with a low Operating Temperature Range, apply a wet coat of vapor barrier lap cement on all butt joints and seal the joints with a minimum 3 inch wide vapor barrier tape or band.

B. Protect insulation and jackets from crushing, denting, and similar damage during construction. Do not penetrate or otherwise damage vapor barriers. Remove any insulation, jacket, and vapor barriers damaged during construction and install new material.

C. Provide flashing at joints between insulation jackets, between insulation jackets and insulation covers, and at endcaps. Provide flashing around flange sets, pipe couplings/connections, and joint fittings. Allow adequate clearance between insulation rings, jackets and the joint connection for the removal and reinstallation of hardware during inspection and maintenance activities.

D. Piping Insulation
   1. Install uninterrupted (continuous) insulation as indicated for the specified Insulation Service Conditions (Condensation Control, Energy Conservation, Personnel Protection, or Freeze Protection). Insulate over pipe and all in-line devices such as valves, fittings, flanges, couplings, strainers and other piping appurtenances. Butt insulation firmly together and provide jacket laps and joint strips with lap adhesive. Provide a minimum of 2 inches of lap length. Install jackets with their seams located on the underside of pipe.
   2. Covers overlap the adjoining pipe insulation and jackets.
   3. Install covers with their seams located on the underside of valves, fittings, flanges, couplings, strainers and other piping appurtenances.
   4. Low Operating Temperature Range
      a. Seal off ends of pipe insulation with a vapor barrier coating.

b. Seal covers at edges with vapor barrier adhesive. Secure the ends of covers with vinyl tape. Overlap the jacket and the cover at least one inch with vinyl tape. Do not penetrate vapor barrier.

5. Medium, High, and Very High Operating Temperature Range
   a. Seal ends of insulation with end joint strips and use waterproof adhesive to hold them in place.
   b. Mechanically secure covers using corrosion-resistant tacks pushed into the overlapping throat joint.
6. Insulation for Outdoor Piping
   a. (Not Used)

E. Mechanical Equipment Insulation
1. Unless otherwise specified in this Section, fit insulation to the contours of equipment and secure it with 1/2 by 0.015 inch stainless steel bands. Weld pins or stick clips with washers may be used for flat surfaces and spaced a maximum 18 inches apart. Stagger joints and fill voids with insulating cement.
2. Overlap ends of blanket segments to prevent gaps and voids when the piping and equipment are heated.
3. Secure blankets snugly under nuts and bolt heads to assure complete coverage during operation and to prevent vibration-induced gaps or voids.
4. Secure blankets in strict accordance with the manufacturer's instructions.

F. Flashing
1. Provide flashing at jacket penetrations and terminations. Provide clearance for flashing between insulation system and piping supports.
2. Form aluminum caps to fit over the adjacent jacketing and to completely cover coated insulation. Hold cap in place with a jacket strap.

3.03 INSULATION THICKNESS SCHEDULE

Piping Service[a]	Insulation Service	Location	Fluid Temperature Range, Degrees F	Insulation Thickness in Inches for Nominal Pipe Sizes	
				Runouts up to 2 inches[b]	6 inch and less
Water					
• HPHW[c]	Energy Conservation	Indoors and Outdoors	100-300	1	1
• W3	Freeze protection	Outdoors	50-75	1.5	2

[a] *See specification Section 40 05 02.*

[b] *Runouts to individual terminal units (not exceeding 12 feet in length).*

[c] *Provide aluminum jacketing for all insulated HPHW piping.*

END OF SECTION

SECTION 40 61 13

PROCESS CONTROL SYSTEM GENERAL PROVISIONS

PART 1 GENERAL

1.01 SUMMARY

A. This section specifies general requirements applicable to Sections 40 61 13 through 40 75 00 of these specifications for the process control, instrumentation, communication, network, and signal systems. This work will be referenced as the Process and Instrumentation Control System (PICS) to be provided by a single Systems Integrator (SI) meeting the qualifications section of this specification.

B. System overview. Detailed requirements are in individual related specification sections.
   1. Field Instrumentation:
      a. New field instruments.
   2. Process Control Hardware:
      a. Expansion of an existing control system.
      b. Modification of existing control panels.
      c. Addition of Programmable Logic Controllers.
   3. Process Control Software, Programming, and Integration:
      a. Expansion of an existing control system.
      b. All programming and integration by Systems Integrator.
      c. Coordinated programming and testing responsibilities between supplier and Owner.
      d. Integration with packaged system controls in other sections.
      e. Integration with existing plant network and communication system.
   4. Communications and Networking
      a. Interface to and expansion of existing Owner networks.
      b. Copper communications systems.

1.02 RELATED SECTIONS

A. The requirements of this section are applicable to work specified in Sections 40 60 00 through 40 79 99 of these specifications.

B. Section 40 70 93 – Schedules for Instrumentation of Process Systems.

C. Division 26 - Electrical

1.03 REFERENCES

A. Reference Standards:

1. This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section prevail.
2. Unless otherwise specified, references to documents mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid (or on the effective date of the Agreement if there were no Bids).
3. If referenced documents have been discontinued by the issuing organization, references to those documents mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued.
4. Where document dates are given in the following listing, references to those documents mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, discontinued, or replaced.

Reference	Title
IEEE 100	Standard Dictionary of Electrical and Electronics Terms
ISA 5.4	Instrument Loop Diagrams
ISA 20	Specification Forms for Process Measurement and Control Instrumentation, Primary Elements, and Control Valves
ISA 51.1	Process Instrumentation Terminology
ISA TR20.00.01	Specification Forms for Process Measurement and Control Instruments Part 1: General Considerations
NFPA 70	National Electrical Code (NEC)
NEMA ICS 1	General Standards for Industrial Control and Systems
UL 508A	Standard for Industrial Control Panels
UL 698A	Standard for Industrial Control Panels Relating to Hazardous (Classified) Locations

1.04 DEFINITIONS

A. Abbreviations:

1. dBm: decibel-milliwatts
2. HIM: human interface module
3. HMI: human-machine interface
4. OIT: operator interface terminal
5. PCS: plant control system
6. PICS: Process and Instrumentation Control System
7. PLC: programmable logic controller
8. RTU: remote terminal unit
9. SCADA: supervisory control and data acquisition
10. SI: Systems Integrator

B. Definitions—General:

1. General: Definitions of terminology related to Instrumentation and Industrial Electronic Systems used in the specifications as defined in IEEE 100, ISA 51.1, and NEMA ICS 1.
2. Data sheets: Data sheets refer to ISA 20 or ISA TR20.00.01, as referenced within ISA-20-1981 specification.
3. Two-wire transmitter: A transducer that derives operating power supply from the signal transmission circuit and requires no separate power supply connections. A two-wire transmitter produces a 4- to 20-milliampere current regulated signal in a series circuit with a 24-volt direct current (VDC) driving potential and a maximum circuit resistance of 600 ohms.
4. Four-wire transmitter: A transducer that derives operating power from separate power supply connections. A four-wire transmitter produces a 4- to 20-milliampere current regulated signal in a series circuit with a maximum circuit resistance of 600 ohms. Four-wire transmitters typically require 120-volt alternating current (VAC) or 24VDC input power supply.
5. Galvanic isolation: An electrical node having no direct current path to another electrical node. Galvanic isolation refers to a device with electrical inputs and/or outputs that are isolated from ground, the device case, the process fluid, and separate power supply terminals. Inputs and/or outputs may be externally grounded without affecting the characteristics of the devices or providing a path for circulation of ground currents.
6. Panel: An instrument support system that may be a flat surface, partial enclosure, or complete enclosure for instruments and other devices used in process control systems including consoles, cabinets, and racks. Panels provide mechanical protection, electrical isolation, and environmental protection from dust, dirt, moisture, and chemical contaminants that may be present in the atmosphere.
7. Systems Integrator: A firm engaged in the business of detailed control system design and engineering, instrumentation component purchase, system and panel assembly, control device programming, and implementing of the specified process control and industrial automation systems.
8. Impulse line: A small-gauge pipe that is used to connect a point in a pipe in which the pressure is measured at an instrument. In flow measurement using a primary device such as an orifice plate, nozzle or Venturi meter, impulse lines are used to connect upstream and downstream (or throat) points of the meter to a secondary device for measuring the differential pressure.

C. Definitions—Signal Types:

1. Analog, low level: Signal with full output level of 100 millivolts or less including thermocouples and resistance temperature detectors.
2. Analog, high level: Signals with full output level greater than 100 millivolts but less than 30 volts, including 4 to 20 mA transmission.
3. Audio signals, high level: Audio signals exceeding plus 4 dBm, including loudspeaker circuits.
4. Digital code: Coded information from the output of an analog-to-digital converter or digital transmission terminal.
5. Discrete control or events: Dry contact closures and signals monitored by solid-state equipment, relays, or control circuits.

6. Discrete control or events, low voltage: Dry contact closures and signals monitored by solid-state equipment, relays, or control circuits operating at less than 30 volts and 250 milliamperes.
7. Modulated signals: Signals from modems or low-level audio signals. Normal signal level: plus 4 dBm to minus 22 dBm. Frequency range is 300 to 10,000 hertz.
8. Pulse frequency: Counting pulses emitted from speed or flow transmitters.
9. Radio frequency (RF) signals: Continuous wave alternating current signals with fundamental frequency greater in a range of 310 kilohertz to 300 gigahertz.

D. Definitions—Drawing Types:
   1. Elementary or schematic diagram:
      a. Use graphic symbols to indicate the electrical connections and functions of a specific circuit arrangement. The schematic diagram facilitates tracing of the circuit and its functions without regard to the actual physical size, shape, or location of the component devices or parts.
      b. Indicate connections to internal and external components connected to the panel. Note which devices are external to the panel.
      c. Depicted in ladder logic format.
      d. Indicates contact arrangement of internal and external devices such that circuits are complete and match equipment furnished.
      e. Indicates equipment designations/tag numbers to match contract drawings and P&IDs.
   2. Block diagram: A diagram of a system, instrument, computer, or program in which selected portions are represented by annotated boxes and interconnecting lines.
   3. Network block diagram:
      a. A diagram of the overall control system, containing annotated boxes showing the primary network components (controllers, hubs, routers, switches, computers, displays).
      b. Include annotated interconnecting lines showing the system communication media and communication protocols.
      c. Indicate manufacturer and model of the primary network components and software.
      d. Indicates functions performed by each device (e.g., Historical Data Server, Field controller, Database Server, Operator workstation, etc.)
   4. Connection diagram:
      a. Purpose is to show wiring requirements between internal panel components.
      b. Show components of a control panel in an arrangement similar to the actual panel layout.
      c. Indicate internal wiring between components.
      d. Show terminal blocks used for internal wiring and field wiring, with identification as such.
      e. Indicate insulation color code, signal polarities, wire numbers, and terminal block numbers.

5. Interconnection diagram:
    a. Purpose is to show wiring requirements between panels, standalone devices, components, and instruments.
    b. Indicate wire numbers, cable numbers, raceway numbers, terminal box numbers, terminal block numbers, panel numbers, and field device tag numbers.
    c. Show external connections between terminals of equipment and outside points, such as motors and auxiliary devices.
    d. Indicate references to connection diagrams that interface to the interconnection diagrams.
    e. Interconnection diagrams are to be of the continuous line type. Show bundled wires as a single line with the direction of entry/exit of the individual wires clearly shown. Wireless diagrams and wire lists are not acceptable.
    f. Show termination of each cable. Clearly mark each termination point. Show each wire's identification as actually installed. The wire identification for each end of the same wire shall be identical. Identify devices and equipment.
    g. Depict terminal blocks as actually installed and identified in the equipment with individual terminal identification.
    h. Indicate external jumpers, shielding, and grounding terminations.
    i. Indicate polarities for signal and DC circuit.
    j. Depict spare wires and cables installed or slated for installation.
6. Arrangement, layout, or outline drawings:
    a. Show the physical space and mounting requirements of a piece of equipment.
    b. Indicate ventilation requirements and space provided for connections or the location to which connections are to be made.
    c. Indicate clearance requirements for ventilation and access.
    d. Show the dimensioned external and interior control panel views with components and Bill of Material.
7. Loop diagrams:
    a. Prepared per ISA 5.4.
    b. Show device element wiring of the system. Indicate device terminations, with terminal numbers.
    c. Show circuits for hardwired device interlocks.
    d. Show circuit cable and wire cable numbers, signal polarities, and terminal block numbers.
    e. Show connection to power supplies. Include alternating current (AC) and direct current (DC) power supplies and circuit information for instruments furnished under this contract.
    f. Indicate controller or I/O card address/node, rack, slot, and point wiring terminals.
    g. Show power supplies for signal loops. Indicate in which panel components reside and power originates with circuit numbering/name. Where new/modified loops connect to an existing power supply, show the existing power supply name, location, and circuit.
    h. Indicate surge protection type, manufacturer, and model number (i.e., types include floating ground reference or grounded reference).

i. Show new and modified terminal blocks with numbering in new and existing panels.

j. Indicate signal loop grounding terminations.

k. Indicate loop numbers, wire numbers, and cable numbers used in field wiring and panel wiring.

l. Indicate field element being controlled or monitored (i.e., normally open contact from relay CR17, or FIT 365).

1.05 ADMINISTRATIVE REQUIREMENTS

A. Coordination:

1. Coordinate the process and instrumentation control system for proper operation with related equipment and systems specified in other Divisions.
2. Integrate equipment in conformance with the drawings, specifications, and recommendations of the equipment manufacturer and the related processes equipment manufacturers.
3. Obtain manufacturer's technical information for items of equipment not provided with, but connected to, the control system. Provide the necessary coordination and components for correct signal interfaces between equipment and the control system.
4. Coordinate interface requirements and schedule with other project subcontractors and equipment suppliers.
5. Present to the Construction Manager conflicts between the plans, specifications, manufacturer/vendor drawings, and installation instructions, etc. for resolution before proceeding.

1.06 SUBMITTALS

A. General:

1. Procedures: Section 01 33 00.
2. This article indicates general requirements applicable to all PICS submittals. Additional information to be submitted with each section will be listed under Submittals in this and each related section.
    a. Submit all information for sections covered by a submittal as a complete package in one submittal. Partial submittals of a section from multiple vendors showing contractor's division of equipment, labor, or portions of the work are not acceptable.
    b. Include a table of contents in each submittal divided by specification section and content of each section such as drawings and components. Clearly indicate the article or paragraph to which each table of content item applies.
    c. Related sections indicate additional detail for each submittal.
    d. Bookmark PDF submittals to match the table of contents of each submittal. Submitted information is to conform to the following:
        1) Shop Drawings: Prepare drawings in AutoCAD version 2021 or greater with borders and title blocks identifying the project, system, revisions to the drawing, and type of drawing. Include a date and description for each revision of a drawing including the date and description of the revisions. Drawing prints shall be 11" by 17" with a minimum lettering size of 1/8".

2) Product Literature: Provide manufacturer's specifications, data sheets, and catalog literature for the equipment and components that clearly and unambiguously show what is being provided and that it meets the requirements specified. Indicate provided and available options, materials of construction, environmental characteristics, electrical characteristics, and connection requirements. Include only applicable information.

e. Conformance with Contract Documents:

1) Provide a copy of sections applicable to the submittal group with addendum updates included, with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements.

2) Check-marks (✓) denote full compliance with a paragraph as a whole. Underline deviations and denote them with a number in the margin to the right of the identified paragraph. Paragraph portions not underlined signify specification compliance. Include a detailed, written justification for each deviation. Show conformance with all paragraphs in a section. Failure to include a copy of the marked-up specification sections and justification(s) for requested deviations is cause for rejection of the entire submittal with no further consideration.

3) Mark a copy of the contract document control diagrams and process and instrumentation diagrams relating to the submitted equipment, with addendum updates that apply to the equipment in this section, to show specific changes necessary for the equipment proposed in the submittal. If no changes are required, mark the drawing or drawings "no changes required." Failure to include copies of the relevant drawings with the submittal is cause for rejection of the entire submittal with no further review. Contract drawings would include the following:

a) Network system diagrams

b) Process and instrumentation diagrams

c) Equipment installation details

4) Show conformance across suppliers and vendors in one submittal. Partial submittals from multiple vendors showing contractor's division of labor or portions of the work are not acceptable.

5) Provide a detailed written request and explanation for each deviation. Failure to include a copy of the marked-up specification sections and drawings, along with justification(s) for requested deviations to the contract requirements, with the submittal, is cause for rejection of the entire submittal with no further consideration.

B. General Requirements for Closeout Submittals

1. Procedures: Section 01 78 23.
2. Provide record drawing prints of drawings and schedules following project startup, but prior to acceptance of the work, showing the final constructed state of the process instrumentation and control systems.
3. Include the following in each operation and maintenance manual:
   a. Final reviewed submittals, including revised as-built record drawings.
   b. Manufacturer's operation and maintenance instructions, edited for this project.

c. Written record of menu configuration, jumpers, switch settings, and other configurable parameters for each instrument.
d. Final application software configurations, in the software native format. Include a comprehensive report print-out from each controller CPU in full color. Provide in Adobe PDF format on electronic media.
e. Final network equipment software configurations.

4. Markup of existing O&M documentation that show modifications to existing panels, communications, and loops/wiring.
5. Maintenance Material Submittals
   a. Provide one listing of spare parts that is divided by specification section.
   b. Include list prices for spare parts, expendable supplies, and tools.
   c. Indicate spare parts packaging and storage methods.
   d. Indicate spare parts or components that could be deleted or reduced based on manufacturer's recommendations.
   e. Indicate where manufacturer's recommendations exceed the spare parts specified.
   f. Obtain spare parts from the equipment manufacturer. Do not provide third-party equivalent replacements.
   g. Packaging, Testing, and Storage:
      1) Provide protective toolboxes for special tools.
      2) Test spare boards, circuit cards, power supplies, and similar spare electronic assemblies on site prior to acceptance.
      3) Carefully repackage operable parts. Immediately remove inoperable parts from the site and order replacement parts. Test replacement parts prior to acceptance.
      4) Package spare parts for protection against dirt and moisture. Label each package as to its contents with a description and part number.
      5) Do not place spare parts for different equipment items in the same package.

C. Action Submittals
1. Quality Assurance (within 30 days of contract Notice to Proceed):
   a. Systems Integrator qualifications per paragraph 1.07, Quality Assurance.
   b. Project personnel qualifications per paragraph 1.07, Quality Assurance.

D. Closeout Submittals
1. Provide record drawing prints of drawings and schedules following project startup, but prior to acceptance of the work, showing the final constructed state of the process instrumentation and control systems.

1.07 QUALITY ASSURANCE

A. All work covered by Sections 40 60 00 through 40 79 99 shall be the responsibility of a single Systems Integrator as defined within this article.

B. The instrumentation and control system functions are shown on the drawings and specified in subsequent sections of Division 40. The Systems Integrator drawings and integration practices shall be as defined in IEEE 100, ISA 51.1, and NEMA ICS 1.

C. Demonstrate the overall system performance to the Owner for acceptance.

D. Systems Integrator qualifications:
   1. Evidence of Experience—Company specializing in the products and work of this section and related sections:
      a. Minimum of 3 years of documented experience with the equipment specified as well as overall systems responsibility for systems of similar size and complexity.
      b. Experience in performing three similar successful projects (equipment type, software type, Systems Integrator responsibilities, complexity, and dollar value of work performed by Systems Integrator) in the last 5 years. At least one project currently in progress or completed within the last 2 years.
      c. End-user satisfaction of projects in the past 3 to 5 years based on end-user interviews by the Owner or Engineer. Submit project descriptions of projects completed within the past 5 years with contact names, addresses, and telephone numbers from the project Owner, General Contractor, and Principal Design Firm.
      d. Financial resources available and projected for successful completion of this project. Submit financial data for Systems Integrator division when subsidiary to a parent corporation. Include 2 years of financial data:
         1) Financial statement.
         2) Balance sheet.
         3) Dun & Bradstreet Report.

E. Systems Integrator Personnel Qualifications: Provide qualified personnel to complete the work specified for this project. Demonstrate by including the following:
   1. Organization chart and resumes for proposed project personnel showing experience and relevant training and certification information for the proposed roles on this project. Provide qualifications for the personnel minimum project roles:
      a. Project manager
      b. Systems engineer
      c. Programmer
      d. Field instrument technician

1.08 ENVIRONMENTAL CONDITIONS

A. Ambient conditions: Per Section 01 11 80

B. Corrosive locations: Per Division 26.

C. Hazardous (Classified) areas: Per Division 26 and on the contract drawings.

D. Seismic:
   1. Brace equipment and supports per Section 01 73 24.

PART 2 PRODUCTS

2.01 EQUIPMENT/MATERIALS

A. General requirements:
   1. New.
   2. Free from defects.
   3. Rated for the installed environment.

B. Similar control system components, instrument, instrument accessory, and devices used throughout the work shall be manufactured by one firm, where possible.

C. The components, modules, devices, and control system equipment shall be recognized industrial-quality products. Recognized commercial- or office-grade products are prohibited.

D. Identification of Listed Products: Provide process measurement devices listed and labeled for the purpose for which they are to be used and the installation environment, by an independent testing laboratory. Three such organizations are Underwriters Laboratories (UL), Canadian Standards Association (CSA), and Factory Mutual (FM). Independent testing laboratory need be acceptable to the inspection authority having jurisdiction.

E. Use electronic equipment of solid-state construction with printed or etched circuit boards of glass epoxy of sufficient thickness to prevent warping.

2.02 SOFTWARE

A. Software packages are to be latest versions available or compatible with existing software currently in use.

2.03 ENCLOSURES

A. Table A specifies the instrument and control panel enclosure material and minimum NEMA rating for the location and application where not identified in other specification sections.

TABLE A

Location	Enclosure Material and NEMA Rating
Indoor: architecturally finished area	NEMA 12: mild steel
Indoor: electrical room	NEMA 12: mild steel
Indoor: process areas	NEMA 4X: 316 stainless steel
Indoor: corrosive area	NEMA 4X: 316 stainless steel
Outdoor: corrosive area	NEMA 4X: 316 stainless steel
Outdoor: non-corrosive areas	NEMA 4X: 316 stainless steel
Corrosive area (hypochlorite)	NEMA 4X: non-metallic
Hazardous area	NEMA 7: galvanized malleable iron or aluminum or NEMA 4X: and UL listed or FM approved for the hazardous area. Where no such enclosure is available, enclosure ratings shall be for the indoor or outdoor area and shall be made intrinsically safe.

Location	Enclosure Material and NEMA Rating
Hazardous and corrosive area	NEMA 7: iron or aluminum with factory-applied corrosion-resistant coating or NEMA 4X: and UL listed or FM approved for the hazardous area. Where no such enclosure is available, enclosure ratings shall be for the indoor or outdoor area and shall be made intrinsically safe.

2.04 NAMEPLATES

A. Provide nameplates for field-mounted instruments, analyzer, panels, and equipment covered by this section with the following requirements:
   1. Include the equipment or instrument loop title and the instrument or equipment tag number, where nameplate engraving is not specified or shown.

B. Nameplate wording may be changed without additional cost or time if changes are made prior to commencement of engraving.

C. For instruments and other equipment located in process areas, provide stainless steel tags with braided stainless steel straps where not stand-mounted.

D. For equipment located in electrical rooms, provide machine engraved white phenolic with black 5/32-inch-high lettering (as minimum), unless otherwise specified or shown; attach nameplates with a minimum of two self-tapping type 316 stainless steel screws.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verify field measurements prior to fabrication.

3.02 INSTALLATION

A. General:
   1. Install equipment in locations that are accessible for operation and maintenance services.
   2. Installation, calibration, settings, and testing procedures are specified in Section 40 61 13, Section 40 70 93, and subsequent sections of Divisions 26 and 40.
   3. Equipment and instruments located in classified areas shall be installed in accordance with the manufacturer's requirements for installation, including classified areas. The installation shall meet the requirements for protection techniques or methods required by the NEC.

B. Field Equipment:
   1. Provide equipment with ports and adjustable items accessible for in-place testing and calibration. Install equipment between 48 inches and 60 inches above the floor or permanent work platform. Equipment shall be mounted to avoid shock or vibration that may impair operation. Equipment shall be mounted for unobstructed access and walkways. Equipment support systems shall not be attached to handrails, process piping or mechanical equipment.

2. Instruments and cabinets supported by concrete walls shall be spaced 5/8 inch by framing channel between instrument or cabinet and wall. Block wall shall have additional installation supports, as required, to avoid damage to the wall. Equipment support material shall be, as shown or specified.
3. Support systems including panels shall be designed in accordance with Section 01 73 23 to prevent deformation greater than 1/8 inch in any direction under the attached equipment load and under an external load of 200 pounds.
4. In wet or outdoor areas, conduit penetrations for connection shall be made through the bottom (preferred) or side of enclosures to minimize water entry from around or from inside of conduits. Provide conduit hubs for connections and waterproof mastic for moisture sealant.

C. Electrical Power Connections:
1. Equipment electric power devices and wiring shall comply with Division 26.
2. Provide power disconnect switches for all instruments, equipment, and panels within sight of equipment and labeled to indicate the specific equipment served and the power source location. "Within sight of" is defined as having an unobstructed view from the equipment served and within 50 feet of the equipment served.
3. Equipment power disconnect switches shall be mounted between 36 inches and 72 inches above the floor or permanent work platform. Where equipment location requirements cannot be met by a single disconnect switch, provide two disconnect switches: one at the equipment and one at the work platform.

D. Signal Connections:
1. Equipment electric signal connections shall be made on terminal blocks or by locking plug and receptacle assemblies. Flexible cable, receptacle and plug assemblies shall be used where shown or specified.
2. Jacketed flexible conduit shall be used between equipment and rigid raceway systems. Flexible cable assemblies may be used where plug and receptacle assemblies are provided and the installation is not subject to mechanical damage in normal use. The length of flexible conduit or cord assemblies shall not exceed 2 feet except where sufficient length is required to allow withdrawal of instruments for maintenance or calibration without disconnection of conduit or cord assemblies.

3.03 INTEGRATION WITH OTHER SYSTEMS

A. Integrate the Screw Presses specified in Section 46 76 27.

3.04 FIELD QUALITY CONTROL

A. Delivery Inspection:
1. Notify the Owner's Representative upon arrival of material or equipment to be incorporated into the work. Remove protective covers or otherwise provide access in order that the Owner's Representative may inspect such items.
2. Provide receipt verification prior to installation. Check:
a. Equipment received is equipment ordered.
b. Equipment meets specified requirements and approved submittals.
c. Equipment has correct manufacturer manuals.
d. Equipment has been factory calibrated.

B. Inspection and Installed Tests:
   1. Refer to Section 40 61 21.

3.05 CLEANING

A. Execute final cleaning prior to final project assessment.

B. Clean surfaces exposed to view, remove temporary labels, and foreign substances.

C. Remove waste and surplus materials, rubbish, and construction facilities from site.

END OF SECTION

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SECTION 40 61 21

PROCESS CONTROL SYSTEM TESTING

PART 1 GENERAL

1.01 SUMMARY

A. This section specifies testing requirements applicable to Sections 40 60 00 through 40 79 99 of these specifications for the process control, instrumentation, communication, network, and signal systems. This work will be referenced as the Process and Instrumentation Control System (PICS) to be provided by a PICS Testing Manager meeting the Qualifications section of this specification. Section includes:

1. Testing documentation.
2. Testing organization and sequencing.
3. Performance testing.
4. Loop testing.
5. Functional testing.
6. Operational testing.

B. Related sections:

1. Section 01 99 90 – Reference Forms (for testing forms)
2. Section 40 61 13 – Process Control System General Provisions
3. Section 40 61 93 – Process Control System Input/Output List
4. Section 40 61 96 – Process Control Descriptions
5. Section 40 70 93 – Process Control System Instrument List

1.02 REFERENCES

A. Definitions:

1. The term “instrumentation” covers field and panel instruments, analyzers, primary sensing elements, transmitters, power supplies, and monitoring devices.

B. Reference Standards:

1. This section contains references to the following documents with additional references listed in Section 40 61 13.
    a. References are part of this section as specified and modified. In case of conflict between the requirements of this section and those of the referenced documents, the requirements of this section prevail.
    b. Version: Latest documents in effect at the time of Advertisement for Bids or Invitation to Bid (or on the effective date of the Agreement if there were no bids) unless noted otherwise.
    c. If referenced documents have been discontinued by the issuing organization, use the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued.

d. Where document dates are given in the following listing, reference to those documents means the specific document version associated with that date, whether the document has been superseded by a version with a later date, discontinued, or replaced.

Reference	Title
ISA RP7.1	Pneumatic Control Circuit Pressure Test
ISA S51.1	Process Instrumentation Terminology

1.03 ADMINISTRATIVE REQUIREMENTS

A. Coordination:
   1. Coordinate testing with Section 01 45 23.
   2. Provide notice to the Owner prior to conducting a test.
   3. Provide a detailed step-by-step test procedure, between 60 and 70 days before the commencement of testing activity, complete with forms for the recording of test results, testing equipment used, and a place for identification of the individuals performing and witnessing the test.
   4. Provide detail assistance to the Contractor in generating Section 01 45 23-Form A (included in Section 01 99 90), customized for this project. Submit detailed form prior to testing per the requirements of Section 01 45 23.
   5. Equipment and System Performance and Operational Testing: Section 01 45 23 specifies testing of the mechanical, electrical, instrumentation, and HVAC systems. Coordinate, manage, and supervise the work with the quality assurance program including:
      a. Testing plan with the sequence for the test work.
      b. Calibration program for instruments and analyzers.
      c. Documentation program that records tests results.
      d. Performance testing program systems.

1.04 SUBMITTALS

A. Procedures: Section 01 33 00.

B. Action Submittals:
   1. Quality Assurance submittal:
      a. PICS Testing Manager Qualifications according to paragraph 1.05.
      b. Testing Technician Qualifications according to paragraph 1.05.
   2. Testing submittal:
      a. Submit after approval of Quality Assurance submittal.
      b. Submit detailed testing plan and proposed testing documentation showing conformance with Part 2 of this specification. Obtain approved submittal prior to testing:
         1) Control descriptions.
         2) Input/Output (I/O) interface.
         3) Testing status spreadsheets.

4) Test procedures.

5) Proposed test forms per this section, detailed for each test for this project.

C. Closeout Submittals

1. Final Test Report assembled in a three-ring binder and submitted at the completion of the inspection and testing activities for a process area.

   a. Label the binder cover and spine to identify the project name and process area. Include in the test report the applicable test procedures for the process area and the completed inspection and test report forms associated with the equipment and systems of that area.

   b. Organize test results by equipment item or system with individual, labeled tab dividers to identify each. The responsible testing entity is to acknowledge system deficiencies and noncompliant test results identified in the final test report as corrected.

   c. Documentation of network data communication nodes for network-type instruments, devices, and variable-frequency drives.

   d. Test equipment and test equipment calibration date.

   e. Performance test results.

   f. Loop test results.

   g. Functional test results.

   h. Operational test results.

1.05 QUALITY ASSURANCE

A. Appoint a startup engineer or qualified specialist as PICS Testing Manager to manage, coordinate, and supervise the testing work.

B. The quality assurance program includes:

1. Definition of process areas and systems, with testing executed on an area-by-area basis, based on the P&ID drawings.
2. Testing for each process area executed in sequential tasks.
3. Regularly updated testing status tracking by process area, system, and task.
4. Regularly updated separate testing documentation for each process system.

C. PICS Testing Manager Qualifications:

1. The PICS Testing Manager shall have at least 5 years of total experience, or experience on at least five separate projects, in managing the testing and startup of similar electrical and instrumentation control systems.

D. Testing Technician Qualifications:

1. Employ technicians who are qualified by completion and certification from training courses offered by the International Society of Automation (ISA), the instrumentation and analyzer manufacturer's training courses, or technician training courses at a recognized trade school that specializes in instrumentation calibration.

PART 2 PRODUCTS

2.01 GENERAL

A. Test forms: Conform to the requirements of Reference Forms 40 61 13-A through 40 61 13-K included in Section 01 99 90. Develop additional or detailed forms as necessary to suit complex instrumentation. Use terms on test forms that comply with ISA S51.1.

B. Project Labeling:
   1. The items specifying project labeling herein include the following as a minimum: Owner's name, facility name, project name, and project number.

C. Testing Plan
   1. Include schedule for areas to be tested.

2.02 TESTING DOCUMENTATION

A. Documentation Records:
   1. Develop and maintain a record-keeping system to document progress and completion for each task in each process area or system.

B. Test Report Volumes:
   1. Develop and maintain testing documentation. Always keep documentation available for inspection on site in a location designated by the Owner. Include the following as a minimum:
      a. Three-ring binder with front cover and spine labeled: "Testing Documentation for Salmon Creek Treatment Plant Dewatering Equipment Replacement."
      b. Table of Contents with same labeling as the volume cover with tabs for each section:
      c. Section 1: Control Description
      d. Section 2: I/O Interface
      e. Section 3: Instrument List
      f. Section 4: Test Procedures and Forms

C. Control Description:
   1. Provide a control description outlining operation for each process area's system. The Control Description Specification Section 40 61 96 may be used as a basis.

D. I/O Interface:
   1. Provide I/O spreadsheets including the following for each I/O point:
      a. Information shown in Section 40 61 93.
         1) Complete physical I/O channel designation and addressing or communication I/O register designation.

E. Instrument List:
   1. Provide a detailed Instrument List. The Instrument List from Section 40 70 93 may be used as a basis. Indicate actual calibration ranges, set points, and deadbands.

F. Test Procedure Documentation:
   1. Organize and assemble test procedures for each loop in the process control system. Submit final test records in electronic form by scanning and converting the records and files to Adobe PDF format, to preserve actual signatures and signoffs.
      a. Include test report forms for each loop, including forms for wiring, piping, and individual component tests.
   2. Preprint and populate information in the test report forms to the extent possible prior to commencing testing.
   3. Include on the test report forms:
      a. Project name.
      b. Process area associated with the equipment under test.
      c. Instrument loop description.
      d. Instrument loop identification number.
      e. Instrument nameplate data.
      f. Instrument setup and configuration parameters.
      g. Time and date of test.
      h. Inspection checklist and results.
      i. Reference to applicable test procedure.
      j. Expected and actual test results for each test point in the loop including programmable controller data table or register values.
      k. Test equipment used.
      l. Space for remarks regarding test procedure or results, observations, etc.
      m. Name, date, and signature of testing personnel.
      n. Test witness's name and signature

PART 3 EXECUTION

3.01 GENERAL

A. General Requirements:
   1. Provide the labor, tools, material, power, and services necessary to provide the process instrumentation and control system inspection and testing specified herein.
   2. Inspect materials, equipment, and construction included under this specification in accordance with this section and subsequent sections of this division. Perform testing in accordance with this and subsequent sections of this division.
   3. Have a certified instrument technician qualified to calibrate the instrumentation calibrate and set up field instruments and analyzers.

B. Test Equipment and Materials:
   1. Provide test equipment to conduct the specified tests that simulate inputs and read outputs with a rated accuracy at the point of measurement at least three times greater than the component under test.
   2. Provide a calibration sticker on test instruments showing date of calibration, deviation from standard, name of calibration laboratory and technician, and date recalibration is required. Include certified calibration reports traceable to the National Institute of Standards and Technology with the final test report.

3. Provide a documenting calibration system to conduct process instrumentation calibration activities that consist of a documenting process calibrator and an instrumentation data management software system that captures the calibration results and electronically document instrument data, date of calibration, calibration procedures, and as-found and as-left instrument calibration data.
4. Provide an instrument calibration system. Submit calibration files with the final test report in hard-copy and electronic formats that does not require specialized equipment or software to read and print the files.
5. Provide buffer solutions and reference fluids for tests of analytical equipment.
6. Provide a communications and software package to record final configuration parameters and settings for variable-frequency drives with the parameters acquired by connection to the network that record the configuration settings without manual data entry or transcription of values.
7. Vendor software tools may document the systems where a licensed copy of the identical software including connectors, cables, keys, interface cards, and devices required for operation is submitted with the final documentation files.

C. Witnessing:
1. The Owner and Owner's Representative reserve the right to observe factory and field instrumentation testing and calibration procedures. Notify the Owner prior to testing, as specified herein.

3.02 TESTING SEQUENCE

A. Perform tests for each area or system in the following sequence:
1. Performance testing
2. Loop testing
3. Functional testing
4. Operational testing

B. Group equipment and I/O based on the relationship of the equipment to operate safely as specified, including full automatic and manual control and monitoring through the control system. Equipment and I/O in a given area or system shall pass testing prior to proceeding to the next set of tests in the sequence above.

3.03 PERFORMANCE TESTING

A. Perform tests in the order below.

B. Wiring Tests:
1. Verify that electrical power and signal cable ring-out and resistance testing has been performed as specified in Sections 26 05 00 and 26 08 00. Conduct wiring tests after cables have been properly terminated, tagged, and inspected.
a. Power and Control: Section 26 08 00.
b. Signal: Section 40 61 13-Form A (included in Section 01 99 90).

C. Network Cable Inspection and Testing:
   1. Test and verify control and instrumentation bus cabling using the standards that apply to the specific cable and bus type as follows:
      a. Ethernet Category 5E and Category 6: per TIA/EIA-568B standards.
   2. Pre-Active Testing: Inspect and test cables prior to energizing to verify the following:
      a. Media type and specifications.
      b. Physical routing and project-specific cable identification tagging.
      c. Correct termination installation and connection of conductors to pins at terminations.
   3. Active System Testing: After the cable or network system has been activated for testing, provide diagnostic monitoring and signal analysis for the bus network system to evaluate network and bus integrity and data transfer quality. Measure, verify, and record the following parameters:
      a. Node addressing.
      b. Baud rate, message traffic rate, percent bandwidth used, error rate, and lost packet count.
      c. Correct the functionality of networks and devices connected to the network.

D. Piping Tests:
   1. Pneumatic Piping Systems: Test pneumatic piping systems for leaks in compliance with ISA RP7.1, except performed at 10 times the normal system operating pressure.
   2. Test Section 40 61 13-Form B (included in Section 01 99 90).
   3. Liquid Piping Systems: Tested for leaks in compliance with Section 40 05 01.

E. Instrument and Component Inspection:
   1. PICS components inspection activities include the following:
      a. Compare and validate instrument type and nameplate data with the drawings, specifications, and data sheet.
      b. Validate instrument identification tag.
      c. Confirm that instrument installation conforms to drawings, specifications, and manufacturer's instructions.
      d. Verify proper conductor termination and tagging.
      e. Visually check for physical damage, dirt accumulation, and corrosion.
      f. Verify that isolation amplifiers, surge protection, and safety barriers are properly installed.
      g. Report deficiencies identified within 24 hours of discovery. No instrument or system component shall be tested until deficiencies are addressed.

F. Instrumentation Calibration:
   1. Calibrate instruments and final elements in accordance with the manufacturer's recommended procedures and tested in accordance with the Contractor's test procedure.
   2. Complete and document instruments and component inspections to the satisfaction of the Owner prior to individual component calibration and testing.

3. Calibrate analog instrument at 0, 10, 50, 90, and 100 percent of the specified full-scale range. Adjust each signal sensing trip and process sensing switch to the required setting. Verify instrument readout matches loop signal. Test data recorded on test forms as specified herein.
4. Test and adjust final element alignment to verify that each final element operates smoothly over the full range in response to the specified process control signals.
5. Enter test data on the applicable test forms at the time of testing: set alarm trips, control trips, and switches to initial values specified in Section 40 70 93 Instrument List at this time. Check final elements for range, deadband, and speed of response.
6. Have any component repaired or replaced by the manufacturer where the component fails to meet the required tolerances. Repeat the specified tests until the component is within tolerance.
7. Install a calibration sticker on each instrument following successful calibration that indicates the date of calibration, the name of the testing company, and personnel who calibrated the instrument.
8. Test forms Section 40 61 13-Form C through I (included in Section 01 99 90).

G. Pre-Loop Testing:
1. Test every I/O point from the field device to the termination on the I/O card in the panel.
2. Perform tests with loop wiring complete and terminated for each point being tested between initial field device and I/O termination point.
3. For each discrete I/O point, verify and document contact status value for both the opened and closed positions of the contact.
4. For analog points, verify analog value matches local display. Confirm calibration at 0, 25, 75, and 100 percent of value.

3.04 LOOP TESTING

A. Provide a request to perform loop testing at least 1 week prior to the requested loop test date. Include the following with the request:
1. Area/system for which request is being made.
2. Written certification that performance testing has been completed, documented, and passed for the area/system for which loop testing is being requested.
3. Submittal numbers that define the tests and data points for the I/O to be tested. Provide updates to the I/O list or instrument calibration as an outcome of the performance testing.

B. Commence loop testing after the performance testing has been completed and documented to the satisfaction of the Owner or Owner's Representative.

C. Test each instrument loop as an integrated system. Check operation from field instruments to transmitter to receiving components to the vendor panel or the Plant Control System Operator Interface Station. Inject test signals at the process impulse line connection where the measuring technique permits, and otherwise at the most primary signal access point.

D. For each discrete I/O point, verify and document field contact status value for both the opened and closed position of the contact.

E. For analog points, verify that analog value matches local display. Confirm calibration at 0, 25, 75, and 100 percent of value.

F. Where loops are interfaced to a controller, verify the controller I/O assignment and operation of the input/output system and processor. Inspect the data table or register in the PLC memory to verify proper operation.

G. If the output control or monitoring device fails to indicate properly, make corrections to the loop circuitry or device. Repeat the test until devices and instruments operate as required.

H. Correct loop circuitry and repeat the test until the instruments operate properly.

I. Test Section 40 61 13-Form J (included in Section 01 99 90).

3.05 FUNCTIONAL TESTING

A. Process Control Strategy/Functional Testing:
   1. Commence control strategy testing after loop testing has been completed and documented to the satisfaction of the Owner or Owner's Representative.
   2. Control strategy testing will be performed by the Programmer. This testing consists of installing and debugging the PLC control logic program, verifying the interface points between the controller I/O cards and field devices and equipment, and exercising the control strategies. Perform control strategy testing on one PLC at a time.
   3. Provide qualified personnel to immediately correct deficiencies in the work that may be encountered during control strategy testing. Failure of the Contractor to provide such personnel in a timely manner may prolong the time allotted to complete control strategy testing.

B. Control System Closed-Loop Testing:
   1. Commence closed-loop commissioning after the control strategy testing has been successfully completed and documented to the satisfaction of the Owner.
   2. Demonstrate stable operation of each loop under operating conditions. Adjust loop tuning parameters as part of the test.
   3. Tuning parameters: gain (or proportional band), integral time constant, and derivative time constant for each control loop, adjusted to provide 1/4-amplitude damping, unless otherwise specified.
   4. Provide the loop response to a step disturbance for each loop. Provide two graphs for cascaded control loops, one showing the secondary loop response with its set point in manual, and the second showing overall loop response.
   5. Adjust control loops with "batch" features to provide optimum response following startup from an integral action saturation condition.
   6. Provide graph recording showing the response and made at sufficient speed and amplitude to show 1/4 amplitude damping. Label to show loop number and title, and settings of parameters and set point.
   7. Where a loop is controlled under the direction of a PLC, the Programmer will perform the necessary adjustment of loop tuning parameters and set points, record the loop response, adjusting final elements, and ensuring total integrated loop performance as specified.

C. Functional Checkout:
   1. Conduct to verify the operation of discrete and hardwired control devices. Exercise the operable devices and energize the control circuit. Operate control element, alarm device, and interlocks to verify that the specified action occurs.

3.06 OPERATIONAL TESTING

A. Perform the Operational Tests after component and subsystem tests have been completed. Perform the test of the completed system in full operation and demonstrate that functional requirements of this specification have been met.

B. Demonstrate the following:
   1. Each component of the system operates correctly with other components of the system.
   2. Analog control loops operate in a stable manner.
   3. Hard-wired and software equipment interlocks perform correctly.
   4. Process control sequences perform correctly.
   5. Application program performs monitoring and control functions correctly.
   6. Operator interface graphics represent the monitoring and control functions correctly.

END OF SECTION

SECTION 40 61 93

PROCESS CONTROL SYSTEM INPUT/OUTPUT LIST

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Input/output (I/O) list showing the following types of points that interface with the control system:
      a. Points that are hardwired into the control system.
      b. Points that are interfaced to the control system over a communications link.
   2. The I/O list does not include internal software points generated by the control system and used solely within the control system.

B. Related sections:
   1. Refer to Section 40 61 13 – General Requirements for Instrumentation and Control.
   2. Refer to Section 40 61 21 – Process Control System Testing.

1.02 SUBMITTALS

A. Procedures: Section 01 33 00.

B. Submittal grouping: Section 40 61 13.
   1. Submit process and instrument control system instrumentation, hardware, and software together as an integrated system in staged submittal groupings as defined in Section 40 61 13. What should be in each submittal grouping is clarified in the following paragraphs.

C. Action Submittal:
   1. Panels and Consoles submittal group. Submit I/O information applicable to the equipment and panels within the submittal group.

D. Informational Submittal: Provide a copy of the electronic version of the complete list to the Owner, at least monthly, when requested.

PART 2 NOT USED

PART 3 EXECUTION

3.01 FIELD QUALITY CONTROL

A. Refer to Section 40 61 21.

B. Maintain a copy of the complete Input/Output List with modifications during construction in Excel format.

3.02 ATTACHMENTS

A. APPENDIX A – Process Control System I/O List

1. Description of headings in Process Control System I/O List.

Field or Heading	Example	Comment or Description
Tag Number	72-SC-0301-A	See tagging on instrument legend sheets.
Device Function	Screw Press Feed Pump 1 Speed Command	Function of specific IO.
Lower Range Value	0	Lowest possible value of the calibrated range
Upper Range Value	100	Highest possible value of the calibrated range
Alarms	HH = 100 PSIG H = 90 PSIG L = 70 PSIG LL = 50 PSIG	High-High Limit Value for Analog Points High Limit Value for Analog Points Low Limit Value for Analog Points Low-Low Limit Value for Analog Points
Switch Setpoint		For discrete points, setpoint indicates the process limit where change of state occurs.
I/O Type	AO	AI, DI, DO, AO
Signal Type	4-20 mA HART	-20 mA, Ethernet, DeviceNet, Discrete Contact, etc.
Panel	72LCP2501	Number or tag to match contract documents
PLC	72PLC01	Number or tag to match contract documents
Rack	01	Match contract drawing, or if not shown, match to submittal information.
Slot	03	Match contract drawing, or if not shown, match to submittal information.
Channel	07	Match contract drawing, or if not shown, match to submittal information.
P&ID		Contract P&ID drawing
Comments		Optional, as required for clarification.

END OF SECTION

APPENDIX A – PROCESS CONTROL SYSTEM I/O LIST

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APPENDIX A
PROCESS CONTROL SYSTEM I/O LIST

Tag Number	Device Function	Lower Range Value	Upper Range Valve	Low-Low Alarm	Low Alarm	High Alarm	High-High Alarm	Switch Setpoint	I/O Type	Signal Type	Panel	PLC	P&ID	Comments
72-LI-0101	Biosolids Day Tank Level	0 ft	33 ft	NA	NA	NA	NA	NA	AI	4-20 mA	77LCP0101	77PLC0101	95-I-100	
72-SC-0301	Screw Press Feed Pump 1 Speed Command	0%	100%	NA	NA	NA	NA	NA	AO	4-20 mA	77LCP0101	77PLC0101	95-I-100	
72-SI-0301	Screw Press Feed Pump 1 Speed	0%	100%	NA	NA	NA	NA	NA	AI	4-20 mA	77LCP0101	77PLC0101	95-I-100	
72-YC-0301	Screw Press Feed Pump 1 Run Command	NA	NA	NA	NA	NA	NA	NA	DO	Dry Contact	77LCP0101	77PLC0101	95-I-100	
72-YI-0301	Screw Press Feed Pump 1 In Remote	NA	NA	NA	NA	NA	NA	NA	DI	Dry Contact	77LCP0101	77PLC0101	95-I-100	
72-YL-0301	Screw Press Feed Pump 1 Running	NA	NA	NA	NA	NA	NA	NA	DI	Dry Contact	77LCP0101	77PLC0101	95-I-100	
72-YA-0301	Screw Press Feed Pump 1 Common Fail	NA	NA	NA	NA	NA	NA	NA	DI	Dry Contact	77LCP0101	77PLC0101	95-I-100	
72-SC-0302	Screw Press Feed Pump 2 Speed Command	0%	100%	NA	NA	NA	NA	NA	AO	4-20 mA	77LCP0101	77PLC0101	95-I-100	
72-SI-0302	Screw Press Feed Pump 2 Speed	0%	100%	NA	NA	NA	NA	NA	AI	4-20 mA	77LCP0101	77PLC0101	95-I-100	
72-YC-0302	Screw Press Feed Pump 2 Run Command	NA	NA	NA	NA	NA	NA	NA	DO	Dry Contact	77LCP0101	77PLC0101	95-I-100	
72-YI-0302	Screw Press Feed Pump 2 In Remote	NA	NA	NA	NA	NA	NA	NA	DI	Dry Contact	77LCP0101	77PLC0101	95-I-100	
72-YL-0302	Screw Press Feed Pump 2 Running	NA	NA	NA	NA	NA	NA	NA	DI	Dry Contact	77LCP0101	77PLC0101	95-I-100	
72-YA-0302	Screw Press Feed Pump 2 Common Fail	NA	NA	NA	NA	NA	NA	NA	DI	Dry Contact	77LCP0101	77PLC0101	95-I-100	
72-FI-0401	Screw Press Feed Pump 1 Discharge Flow	0 GPM	150 GPM	NA	NA	NA	NA	NA	AI	4-20 mA	77LCP0101	77PLC0101	95-I-100	Instrument is existing and will be reused for this project
72-FI-0402	Screw Press Feed Pump 2 Discharge Flow	0 GPM	150 GPM	NA	NA	NA	NA	NA	AI	4-20 mA	77LCP0101	77PLC0101	95-I-100	Instrument is existing and will be reused for this project
74-LI-2201B	Sludge Blend Tank Level	0 ft	22 ft	NA	NA	NA	NA	NA	AI	4-20 mA	77LCP0101	77PLC0101	95-I-100	
72-AI-2605	Screw Press 1 Inlet TSS	0 %	5%	NA	NA	NA	NA	NA	AI	4-20 mA	72LCP2501	72PLC01	95-I-101	
72-AI-2705	Screw Press 2 Inlet TSS	0 %	5%	NA	NA	NA	NA	NA	AI	4-20 mA	72LCP2501	72PLC01	95-I-102	
72-AI-2730	Screw Press Combined Filtrate TSS	0 %	0.5%	NA	NA	NA	NA	NA	AI	4-20 mA	72LCP2501	72PLC01	95-I-102	
72-YI-4301	Cake Collection Screw 1 Gate In Remote	NA	NA	NA	NA	NA	NA	NA	DI	Dry Contact	72LCP2501	72PLC01	95-I-104	
72-ZCO-4301	Cake Collection Screw 1 Gate Open Command	NA	NA	NA	NA	NA	NA	NA	DO	Dry Contact	72LCP2501	72PLC01	95-I-104	
72-ZCC-4301	Cake Collection Screw 1 Gate Close Command	NA	NA	NA	NA	NA	NA	NA	DO	Dry Contact	72LCP2501	72PLC01	95-I-104	
72-ZSO-4301	Cake Collection Screw 1 Gate Opened	NA	NA	NA	NA	NA	NA	Valve Open 95%	DI	Dry Contact	72LCP2501	72PLC01	95-I-104	

APPENDIX A
PROCESS CONTROL SYSTEM I/O LIST

Tag Number	Device Function	Lower Range Value	Upper Range Valve	Low-Low Alarm	Low Alarm	High Alarm	High-High Alarm	Switch Setpoint	I/O Type	Signal Type	Panel	PLC	P&ID	Comments
72-ZSC-4301	Cake Collection Screw 1 GateClosed	NA	NA	NA	NA	NA	NA	Valve Open 5%	DI	Dry Contact	72LCP2501	72PLC01	95-I-104	
72-YC-4201A	Cake Collection Screw 1 Start Command	NA	NA	NA	NA	NA	NA	NA	DO	Dry Contact	72LCP2501	72PLC01	95-I-104	
72-YC-4201B	Cake Collection Screw 1 Stop Command	NA	NA	NA	NA	NA	NA	NA	DO	Dry Contact	72LCP2501	72PLC01	95-I-104	
72-YL-4201	Cake Collection Screw 1 Run Status	NA	NA	NA	NA	NA	NA	NA	DI	Dry Contact	72LCP2501	72PLC01	95-I-104	
72-YI-4201	Cake Collection Screw 1 In Remote	NA	NA	NA	NA	NA	NA	NA	DI	Dry Contact	72LCP2501	72PLC01	95-I-104	
78-YC-4499A	Temporary Inclined Screw Start Command	NA	NA	NA	NA	NA	NA	NA	DO	Dry Contact	72LCP2501	72PLC01	95-IT-102	
78-YC-4499B	Temporary Inclined Screw Stop Command	NA	NA	NA	NA	NA	NA	NA	DO	Dry Contact	72LCP2501	72PLC01	95-IT-102	
78-YL-4499	Temporary Inclined Screw Run Status	NA	NA	NA	NA	NA	NA	NA	DI	Dry Contact	72LCP2501	72PLC01	95-IT-102	
78-YI-4499	Temporary Inclined Screw In Remote	NA	NA	NA	NA	NA	NA	NA	DI	Dry Contact	72LCP2501	72PLC01	95-IT-102	

SECTION 40 61 96.00

PROCESS CONTROL STRATEGIES

PART 1 GENERAL

1.1 SUMMARY

A. Scope:

1. These control strategies are not intended to apportion work or responsibility for work among subcontractors, suppliers and manufacturers, but are offered as a guide for programming, startup, and checkout. They describe how the system is to operate, and do not necessarily include every component required to make the system function.
2. Control strategies describe sequential and interlocking control functions, analog control functions, color-graphic video display HMI Computers and Operator Interfaces and alarm and event logging. The System Programmer will provide all necessary software and applications programming to implement the control strategies. All control functions shall be programmed in the PLCs, the Operator Interfaces and HMI computers shall perform supervisory functions.
3. The Owner or Owner's Representative will configure Operator Interface and HMI computer screens for the new equipment being installed to match the look and feel existing HMI process graphic displays. As detailed by the P&IDs and other contract documents and drawings, these screens will show the process conditions, equipment statuses, and alarming for abnormalities of the process and malfunctions of equipment.

1.2 RELATED SECTIONS

A. This section contains specific references to the following related sections. Additional related sections may apply that are not specifically listed below.

1. Section 40 61 13 – Process Control System General Provisions.
2. Section 40 61 93 – Process Control System IO List
3. Section 40 61 96.21 – Control Strategy 21 Screw Press Feed Pumps
4. Section 40 61 96.22 – Control Strategy 22 Screw Presses
5. Section 40 61 96.23 – Control Strategy 23 Conveyors
6. Section 40 61 96.24 – Control Strategy 24 Conveyor Discharge Gates
7. Section 40 61 96.25 – Control Strategy 25 Temp Screw Press

1.3 REFERENCES

A. This Section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this Section as if referenced directly. In the event of conflict between the requirements of this Section and those of the listed documents, the requirements of this section prevail.

1. Unless otherwise specified, references to documents shall mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid (or on the effective date of the Agreement if there were no Bids). If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued. Where document dates are given in the following listing, references to those documents shall mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, discontinued or replaced.

Reference	Title
ANSI/ISA 5.06.01	Functional Requirements Documentation for Control Software
ANSI/ISA 101.01	Human Machine Interfaces for Process Automation

1.4 DEFINITIONS

A. Per ANSI/ISA 5.06.01:

1. Analog Input (AI): A modulated signal received by the control system from an external device, such as a 4-20 mA or fieldbus signal from a pressure transmitter.
2. Analog Output (AO): A modulated signal sent by the control system to an external control device, such as a 4-20 mA or fieldbus signal to a flow control valve.
3. Discrete Input (DI): A binary signal received by the control system from an external switch, such as a 24-Vdc or fieldbus signal from a block valve's closed limit switch.
4. Discrete Output (DO): A binary signal sent by the control system to an external on/off device, such as a 120-Vac or fieldbus signal to start a pump.
5. Operation: A major programmed processing action or set of related actions normally consisting of one or more phases.
6. Piping and Instrumentation Diagram (P&ID): A diagram showing the interconnection of process equipment and instrumentation used to control a process,
7. Process Flow Diagram (PFD): A diagram showing outlines of one or more pieces of equipment and the expected flow paths for materials and utilities.
8. Phase: The smallest element of procedural control that can accomplish a process-oriented task. A phase may be comprised of steps.
9. Step: Sequential action of control devices within a phase.

B. Per ANSI/ISA 101.01:

1. Control System: A system that responds to input signals from the equipment under control and/or from an operator and generates output signals that cause the equipment under control to operate in the desired manner.

2. Human Machine Interface (HMI): The collection of hardware and software used by the operator or other users to monitor and interact with the control system and with the process via the control system.
3. Supervisory Control and Data Acquisition (SCADA): A system for monitoring and control of process which are geographically widespread. This includes all equipment and functions for acquiring, processing, transmitting, and displaying the necessary process information.

C. For the purposes of this section, "Existing" refers to those structures, devices, or items of equipment which were a part of the process system prior to the work done under this Contract

1.5 ADMINISTRATIVE REQUIREMENTS

A. The control strategies are not intended to apportion work or responsibility for work among subcontractors, suppliers and manufacturers, but are offered as a guide for programming, startup, and checkout. The control strategies describe how the system is to operate, and do not necessarily include every component required to make the system function.

B. Coordinate with the Owner's Programmer for testing and commissioning.

PART 2 NOT USED

PART 3 EXECUTION

3.1 CONTROL STRATEGIES

A. The following control strategies are included in this section and describe general control features for all systems.

Control Strategy Number	Title
1	Discrete Point Status
2	Analog Point Status
3	General Ready, Running and Failure Status
4	SCADA Inputs and Outputs Distribution and Control Requirements
5	General Recording System
6	General Contact/Logic System
7	General Closed-Loop Feedback Control
8	Trend Plots
9	Color Notation for Dynamic Objects on Control Graphic Display Screens
10	Discrete Alarm System
11	Discrete Status System
12	Single Speed Motor Starter Signals
13	Variable Frequency Drive Signals
14	Motor Monitoring System
15	Network Monitoring
16	Open/Close Gate Actuator Signals
17	NOT USED
18	NOT USED

Control Strategy Number	Title
19	NOT USED
20	NOT USED

B. Refer to related sections for detailed process control system descriptions.

Control Strategy Number	Title
21	Screw Press Feed Pumps
22	Screw Presses
23	Conveyors
24	Coneyor Discharge Gates

Control Strategy 1
Discrete Point Status

A. Reference Drawings:
   1. All P&IDs.

B. System Components:
   1. In accordance with P&IDs.
   2. System Discrete Points are listed in Section 40 61 93 (IO List).
   3. See Section 40 61 93 for Alarm limits and setpoints.

C. Description:
   1. The status of each discrete input point shall be maintained in the SCADA system database. The status of each logical discrete point shall also be maintained in the SCADA system database. Logical points are points which depend upon the status of one or several discrete input points.
   2. For example, an equipment-failed logical status will result from a loss of ready status when running. Loss of ready status when NOT running will not result in a failed logical status.

D. SCADA:
   1. Calculate and maintain the status of all discrete and logical discrete status points in the SCADA system database.
   2. Record all changes in status in the historian (SCADA recording system).

End of Control Strategy 1

Control Strategy 2
Analog Point Status

A. Reference Drawings:
   1. All P&IDs.

B. System Components:
   1. In accordance with P&IDs.
   2. System Analog Points are listed in Section 40 61 93 (IO List).
   3. See Section 40 61 93 for Alarm limits and setpoints.

C. Description:
   1. Analog input points shall be checked for the following status conditions:
      a. Failed: Point value is less than or greater than the specified value range, typically less than 3.6 mA and greater than 21.6 mA.
      b. Low and Low-Low Alarms: Point value is equal to or less than a predetermined alarm value.
      c. High and High-High Alarms: Point value is equal to or greater than a predetermined alarm value.
      d. Normal: Point value is within the predetermined low and high alarm values.
   2. An analog point which is in alarm status shall not be changed to normal status until the point value changes by the predetermined deadband value for the point.

D. SCADA:
   1. Failed, high alarm, low alarm, and deadband values shall be maintained in the SCADA system database. These limits may be changed via the SCADA programmer.
   2. Point status shall be maintained in the SCADA system database. Discrete alarm outputs shall be driven from the point status.
   3. Calculated Analog Values:
      a. Calculated analog values are values that are computed by PLCs or HMI programming, such as flow rates calculated as the sum or difference of other flows, loading rates, and volumes based on level.
      b. Values calculated by PLCs have the same features as “real” analog inputs with respect to alarming, totalizing, trending, and historical data.

End of Control Strategy 2

Control Strategy 3
General Ready, Running and Failure System

A. Each motor-driven piece of equipment shall have a RUNNING status input to the SCADA system. If the equipment is equipped with one or more HAND-OFF-AUTO switches, the equipment shall have an input for AUTO status. If a "RUNNING" input status occurs and the "AUTO" status does not occur, the SCADA system shall identify that the motor is operating in the HAND mode.

B. The run time shall be calculated and stored for all equipment being monitored. This function shall be equivalent to a conventional elapsed time meter to include the tenth of an hour digit and shall include: Today's Total and Yesterday's total and Cumulative Total. Program a setpoint to set a flag for maintenance of equipment. Program an adjustable timer to set a flag for maintenance of equipment. A summary of equipment requiring maintenance shall be printed out upon plant operator request.

C. The failure of driven equipment shall be monitored by the SCADA system. Equipment shall be considered failed under the following conditions:
   1. The equipment is in AUTO and the SCADA system attempts to operate the equipment and it does not respond within a defined time period.
   2. The equipment is in AUTO and running and for whatever reason other than the SCADA system requesting the equipment to "STOP," the equipment stops.

D. In addition, specific equipment is required to provide "Trouble", "Fault", or other specific alarm inputs to the SCADA system. This input shall be added to the internal logic described in items 1 and 2 above so that any one of these events shall trigger a "FAIL" alarm.

E. The SCADA system shall be used to the extent that it shall facilitate sequencing of the equipment. The plant operator shall be able to bypass the sequencing and START/STOP the equipment and OPEN/CLOSE valves and gates on a "MANUAL" procedure from the hand switches when desired. Interface to the SCADA system shall be through I/O points or workstations or laptops.

F. Equipment shall have an OUT OF SERVICE selection available in SCADA that will allow the equipment to be taken offline for maintenance purposes. When placed OUT OF SERVICE, all equipment SCADA alarms and control capability will be inhibited and the equipment will be skipped over in any automatic control sequencing (e.g. lead-lag-lag pumping sequences).

End of Control Strategy 3

Control Strategy 4
SCADA Inputs and Outputs Distribution and Control Requirements

A. Reference Drawings:
   1. Various P&IDs.

B. Description:
   1. SCADA system I/O assignment shall be as shown on the P&IDs.
   2. Upon failure of a process equipment item, the SCADA system shall start the next available unit, as described in the applicable control strategy.
   3. Upon failure of a PLC input/output module, SCADA system shall skip equipment controlled by PLC input/output module and go to next process unit in the lead-lag sequence.
   4. For example, two pumps' input/outputs shall be equally distributed to two different I/O modules. If three pumps are required and only two input modules and two output modules are available, then as a minimum, two pumps shall be assigned to one set of input/output modules while the third pump shall be assigned to the second set of input/output modules.
      a. Note that "pumps" are used to describe the I/O distribution requirements. The concept shall be extended to all process equipment including, valves, gates, instruments for level, flow, pressure, etc.

End of Control Strategy 4

Control Strategy 5
General Recording System

A. Reference Drawings:
   1. All P&IDs.

B. Description:
   1. HMI workstations shall generate reports based upon process variables (pressure, flow, temperature, level and analytical) and equipment status (speed, and motor current) in real-time and from recent historical data. The exact report requirements will be determined by the Owner and shall be configured by the System Programmer during the project construction period.
   2. All motors greater or equal to 40 hp shall be included under this recording requirement. All instruments shown on the P&IDs with PIR-xxxx. FIR-xxxx, TIR-xxxx, LIR-xxxx, and AIR-xxxx shall also be included under this recording requirement (where xxxx indicates instrument tag number).

End of Control Strategy 5

Control Strategy 6
General Contact/Logic System

A. Reference Drawings:
   1. All P&IDs.

B. Description:
   1. All discrete/logic control functions shall be provided as required and shall include but not be limited to the following:
      a. Discrete/Logic Functions: The ability to perform logic and sequencing functions shall be supported to provide control interlocks, event sequencing and other logic operations.
      b. Boolean Algebra requirements: AND gate, OR gate, NAND gate, NOR gate, XOR gate, and NXOR gate.
      c. Logic requirements: Logic switch, logic compare, bi-directional time delay, and on-off with feedback.
      d. Ladder Logic requirements: NO contact, NC contact, energize coil, latch/unlatch coil, retentive timer on/off delay, up/down counter, counter/timer reset, ladder execution control, immediate input, and immediate output.

End of Control Strategy 6

Control Strategy 7
General Closed-Loop Feedback Control

A. Reference Drawings:
   1. All P&IDs.

B. Description:
   1. All closed-loop feedback control shall be provided as required and shall include but not be limited to the following:
      a. Proportional-Integral-Derivative (PID) Control--Standard controller functions with balanceless, bumpless transfer from manual to automatic, manual overrides, external reset, and output summing capabilities. Provision for cascade, rationing gain, bias, lead-lag, dead-time, and feed forward functions to supplement the feedback control shall be available.
      b. PID control shall be configured to prevent integral windup by eliminating integral error accumulation when the controller output reaches a limit or is not in use.
      c. HMI display system shall have a common PID controller operator interface for all equipment utilizing PID control. Controller operator interface shall include alphanumeric and graphic indication of the following features as a minimum:
         1) Identification of controlled equipment
         2) Identification of process variable input
         3) Controller setpoint value
         4) Process variable value
         5) Controller output value
         6) Setpoint adjustment interface
         7) Indication if setpoint is under local or remote control
         8) Local/Manual control output adjustment interface
         9) Indication if control output is under local/manual control or under control of process controller
      d. Computational Functions: On-line mathematical functions shall be available to provide real-time computational capability of control variables for use in feed-forward and other advanced control functions.
      e. All setpoints for alarm and control shall be adjustable from password-protected HMI Computer screens. Coordinate level of security required for password protection of setpoint screens with the Owner and Engineer.
      f. Appropriate control action(s) shall be provided as needed.

End of Control Strategy 7

Control Strategy 8
Trend Plots

A. Reference Drawings:
   1. All P&IDs.

B. Description:
   1. HMI workstations shall graphically plot trends of process variables (pressure, flow, temperature, level and analytical), controller setpoints and outputs, and equipment status (speed and motor current) in real-time and from historical data. The plant operator shall be able to select the plotting interval, within the limits of the actual data collection. Provide a minimum of four trends per display view.
   2. In addition to the plotted data, a trend shall include:
      a. Time
      b. Date
      c. Tag number
      d. Plotting interval
      e. Time at start
      f. Time at latest value

End of Control Strategy 8

Control Strategy 9
Color Notation for Dynamic Objects on Control Graphic Display Screens

A. Reference Drawings:
   1. All P&IDs, all control strategies.

B. Description:
   1. All dynamic objects on control graphic display screens shall be provided with multiple-color display to identify status.
      a. The color strategies for motors, valves, and all other equipment shall match the existing color strategy.
         1) Coordinate with Owner
         2) Obtain and Match Owner's style sheets.
      b. The alarm color and blinking pattern for all equipment, devices, and instrumentation shall match the existing strategies.
         1) Coordinate with Owner.

End of Control Strategy 9

Control Strategy 10
Discrete Alarm System

A. Reference Drawings:
   1. All P&IDs, electrical control diagrams, and vendor drawings.

B. System Components:
   1. In accordance with P&IDs.

C. Description:
   1. All discrete input alarms shall be provided as shown on P&IDs regardless of whether specific control strategies are provided. Whenever a P&ID is not shown with any On/Off, Start/Stop, Open/Close or analog modulation control, no specific control strategy will be written even if a discrete alarm system is shown on the drawing. For this condition, control strategies 1-16 shall be applicable. Discrete inputs can be from field instruments (level switches, pressure switches, etc.), local control panels (relay outputs, alarm module outputs, switches), and packaged systems (designated terminals with packaged units). A manual reset is required at the equipment control panel; Reset from SCADA is not acceptable.
   2. On a power failure, equipment shall return to the ready state when power is returned. Given the process condition, the lead piece of equipment shall start if called for. The lag and lag-lag, etc., starting sequence shall be staggered at 15-second intervals (adjustable) depending on the process. Operations shall designate this time during startup.

End of Control Strategy 10

Control Strategy 11
Discrete Status System

A. Reference Drawings:
   1. All P&IDs, electrical control diagrams, and vendor drawings.

B. System Components:
   1. In accordance with contract drawings, P&IDs and as called out in the specifications.

C. Description:
   1. All discrete input status shall be displayed on HMI screens as required by the reference drawings and specifications regardless of whether specific control strategies are provided. Each discrete input shall be shown in its appropriate process screen and/or equipment status screen. Discrete inputs can be originated from field instruments (motorized actuators, HVAC related air handling units, power management related contact inputs, level switches, pressure switches, etc.), local control panels (relay outputs, alarm module outputs, switches), and packaged systems (designated terminals with packaged units).
   2. All equipment HOA selector switch Auto mode status contact is to be monitored by the PLC. When the HOA switch is not in the Auto mode the SCADA system shall display “Not in Auto” for that respective piece of equipment.

End of Control Strategy 11

Control Strategy 12
Single Speed Motor Starter Signals

A. Reference Drawings:
   1. All P&IDs, electrical control diagrams, and vendor drawings.

B. System Components:
   1. In accordance with contract drawings, P&IDs and as called out in the specifications.

C. Description:
   1. Each motor starter shall be provided with hardwired interfaces to the SCADA system. This interface provides critical control and monitoring of the motor starter and equipment including the motor.

D. SCADA monitoring:
   1. The SCADA system shall display or annunciate the following conditions for each motor starter and its associated equipment as well as the other conditions described in other control strategies herein:
      a. Off – Display
      b. Running – Display
      c. In Remote – Display
      d. Common Failure – Annunciate
         1) Additional failure information may be provided via networked communication from the motor starter smart overload relay per the specific process control descriptions for each system.
      e. Fail to Run – Annunciate
         1) An operator adjustable timer will monitor “fail to run.”
         2) If the PCS issues a run command (in SCADA Manual or in SCADA Auto), start the “fail to run” timer. If the timer expires and the running status feedback does not indicate that the motor is running, annunciate an alarm indicating the motor has failed to run.
   2. Additional monitoring information will be made available over the network from the motor starter smart overload relay as required by Control Strategy 14.

End of Control Strategy 12

Control Strategy 13
Variable Frequency Drive Interface Signals

A. Reference Drawings:
   1. All P&IDs, electrical control diagrams, and vendor drawings.

B. System Components:
   1. In accordance with contract drawings, P&IDs and as called out in the specifications.

C. Description:
   1. Each variable frequency drive shall be provided with hardwired interfaces to the SCADA system. This interface will provide critical control and monitoring of the adjustable frequency drive and the driven equipment including the motor.

D. SCADA monitoring:
   1. The SCADA system shall display or annunciate the following conditions for each adjustable frequency drive and its driven equipment as well as the other conditions described in other control strategies herein:
      a. Off – Display
      b. Running – Display
      c. Speed Feedback – Display
      d. In Remote – Display
      e. Common Failure – Annunciate
         1) Additional failure information may be provided via networked communication from the motor starter smart overload relay per the specific process control descriptions for each system.
      f. Fail to Run – Annunciate
         1) An operator adjustable timer will monitor “fail to run.”
         2) If the PCS issues a run command (in SCADA Manual or in SCADA Auto), start the “fail to run” timer. If the timer expires and the running status feedback does not indicate that the VFD is running, annunciate an alarm indicating the VFD has failed to run.
      g. Speed feedback mismatch from speed command – Annunciate
         1) If the PCS is controlling the speed of the VFD (in SCADA Manual or in SCADA Auto), and the speed of feedback is not within 1 percent of the speed command, start a 30 second timer. If the timer expires, annunciate an alarm indicating that the VFD speed feedback is mismatched from the VFD speed command.
   2. Additional monitoring information will be made available over the network from the motor starter smart overload relay as required by Control Strategy 14.

End of Control Strategy 13

Control Strategy 14
Motor Monitoring System

A. Reference Drawings:
   1. All P&IDs, electrical control diagrams, and vendor drawings.

B. System Components:
   1. In accordance with contract drawings, P&IDs and as called out in the specifications.

C. Description:
   1. Motors with network connections contain information such as motor monitoring features that may be used for diagnostic information. Where network connections are established according to the contract documents, this information shall be extracted from the device using the network connection and displayed on the SCADA system. In addition to signals listed in Control Strategies 12 and 13, at a minimum the following information shall be integrated and communicated over the network:
      a. Motor current, each phase
      b. Current unbalance percent
      c. Ground fault current
      d. Thermal capacity
      e. Frequency
      f. Overload status

End of Control Strategy 14

Control Strategy 15
Network Monitoring

A. Reference Drawings:
   1. All P&IDs

B. System Components:
   1. In accordance with contract drawings, P&IDs, and as called out in the specifications including:
      a. VFD drives
      b. Screw Presses

C. Description:
   1. Boolean Data from equipment that is monitored over a communication protocol follows Control Strategy 1 for Discrete Point Status.
   2. Float/Real/Double data from equipment that is monitored over a communication protocol follows Control Strategy 2 for Analog Point Status.
   3. All data from equipment that is monitored over a communication protocol is to be treated in the same manner as hardwired data, including but not limited to alarming, logging, trending, and graphical display. Refer to all Control Strategies herein. Coordinate with Owner for the desired data to integrate from each network-connected device and maintain a list of these data points in excel format including the following:
      a. Device Tag Name
      b. Device IP Address
      c. Device Address/Register (if applicable)
      d. SCADA Tag Name

End of Control Strategy 15

Control Strategy 16
Open/Close Gate Actuator Signals

A. Reference Drawings:
   1. All P&IDs

B. System Components:
   1. In accordance with contract drawings, P&IDs and as called out in the specifications.

C. Description:
   1. Each gate actuator shall be provided with hardwired interfaces to the SCADA system. This interface shall provide critical control and monitoring of the actuator and gate.
   2. Actuators fail in their last position unless otherwise described in the control strategies.
   3. The automatic controls are limited by software interlocks and hardwired interlocks.

D. SCADA Control:
   1. The SCADA system will control the position of the gate when the gate actuator is set to be controlled remotely.
   2. An OPEN COMMAND and CLOSE COMMAND will be sent from SCADA to the actuator.

E. SCADA Monitoring:
   1. The SCADA system shall display or annunciate (as indicated) the following conditions for each gate as well as the other conditions described previously in this Section:
      a. Opened – Display
      b. Closed – Display
      c. In Transition (when neither Opened nor Closed) – Display
      d. Fail to Open – Annunciate
         1) An operator adjustable timer will monitor “fail to open.”
         2) If the PCS issues an open command (in SCADA Manual or in SCADA Auto), start the “fail to open” timer. If the timer expires and the open position switch does not indicate that the gate is opened, annunciate an alarm indicating the gate has “Failed to Open.”
      e. Fail to Close – Annunciate
         1) An operator adjustable timer will monitor “fail to close.”
         2) If the PCS issues a close command (in SCADA Manual or in SCADA Auto), start the “fail to close” timer. If the timer expires and the close position switch does not indicate that the gate is closed, annunciate an alarm indicating the gate has “Failed to Close.”

End of Control Strategy 16

END OF SECTION

SECTION 40 61 96.21

CONTROL STRATEGY 21 - SCREW PRESS FEED PUMPS

A. Reference Drawings:
   1. 95-I-100

B. Equipment

Equipment Tag	Description
72P0301	Screw Press Feed Pump 1
72P0302	Screw Press Feed Pump 2
72T0101	(Existing) Biosolids Day Tank

Instrumentation Tag	Description
72PSH0301	Screw Press Feed Pump 1 Discharge High Pressure Switch
72PSL0301	Screw Press Feed Pump 1 Suction Low Pressure Switch
72TSH0301	Screw Press Feed Pump 1 Motor High Temperature Switch
72FSL0301	Screw Press Feed Pump 1 Seal Water Flow Switch
72SV0301	Screw Press Feed Pump 1 Seal Water Solenoid
72PSH0302	Screw Press Feed Pump 2 Discharge High Pressure Switch
72PSL0302	Screw Press Feed Pump 2 Suction Low Pressure Switch
72TSH0302	Screw Press Feed Pump 2 Motor High Temperature Switch
72FSL0302	Screw Press Feed Pump 2 Seal Water Flow Switch
72SV0302	Screw Press Feed Pump 2 Seal Water Solenoid
72LIT0101	Biosolids Day Tank Level Indicating Transmitter
72FIT0401	(Existing) Screw Press 1 Train Flow Indicating Transmitter
72FIT0402	(Existing) Screw Press 2 Train Flow Indicating Transmitter

C. System Description
   1. The screw press feed pumps consist of two pumps that are used to convey digested sludge from the Biosolids Day Tank to the Screw Press 1 and 2. There are two modes of automatic control for the pumps: Level Control Mode and Flow Control Mode. When in Level Control Mode, one operates as a lead pump and the other operates as a lag pump. When in Flow Control Mode, both pumps are online and operate independently.
   2. The screw press feed pumps are controlled by variable frequency drives which adjust motor speed and change the number of online pumps to either: 1) maintain a level setpoint in the Biosolids Day Tank, as measured by the level transmitter, or 2) maintain independent flow setpoints for each train to the screw presses, as measured by the flow transmitters.
   3. In Level Control Mode, the level setpoint in the Biosolids Day Tank is 10 ft by default as measured by the level transmitter. The level setpoint will be operator adjustable between 8 ft to 12 ft.
   4. In Flow Control Mode, the discharge flow setpoint for each pump is 105 GPM by default as measured by the respective flow transmitter. The flow setpoint will be operator adjustable.
   5. Each pump is equipped with a temperature sensor for motor protection.

D. Control Descriptions

1. Local Manual Control:
    a. Local manual control of the pump can be enabled by setting the local control station LOCAL/OFF/REMOTE selector switch to LOCAL. While in LOCAL the pump runs and has its speed adjusted at the VFD.
    b. Under normal operating conditions, the VFD is set to REMOTE. This enables remote manual control via SCADA control, as specified in the paragraphs below.
    c. Active VFD faults can be manually reset via a reset button on the VFD.
2. Local Auto Control:
    a. None
3. SCADA Manual Control:
    a. When the local control station LOCAL/OFF/REMOTE selector switch is set to REMOTE, SCADA control is enabled. The operator can then select between SCADA Manual or SCADA Automatic control of the pump at the SCADA HMI.
    b. When SCADA Manual control is selected, the operator can manually start and stop the pump and manually adjust the pump speeds via the SCADA HMI.
4. SCADA Auto Control:
    a. When the local control station LOCAL/OFF/REMOTE selector switch is set to REMOTE, SCADA control is enabled. The operator can then select between SCADA Manual or SCADA Automatic control of the pump at the SCADA HMI.
    b. When SCADA Automatic control is selected, the pumps can be operated in 2 modes: Level Control Mode or Flow Control Mode.
    c. When in Level Control Mode, the pumps operate as follows:
        1) Control of the pumps shall be based on the level in the Biosolids Day Tank, as measured by the level transmitter in the tank.
        2) Screw Press Feed Pumps 1 and 2 are each assigned a role: Lead or Lag. Screw Press Feed Pumps 1 and 2 run in a Lead/Lag operational sequence manually set by the operator at the HMI. If SCADA Automatic control is not enabled for the Lead pump or the Lead pump fails to run when it is called to operate, then the Lag pump is assigned the Lead role. If a pump is “Off”, it shall not be started or used in the control scheme.
            a) The Lead and Lag roles will be automatically alternated between the two pumps after an adjustable user-defined run time. The operator can assign roles manually and switch off the auto-alternate feature.
        3) A single PID-type control loop (refer to Control Strategy 7) controls starting and stopping of the pumps and adjusts pump speeds to maintain the level setpoint in the Biosolids Day Tank:
            a) If the Biosolids Day Tank level rises above the level setpoint for an operator-adjustable time delay, the Lead pump shall be called to run. The Lead pump speed is then modulated as necessary to maintain the level setpoint.
            b) If the Lead pump is running at 95% speed or greater for an operator-adjustable time delay, the Lag pump starts and ramps up in speed until both pumps are operating at the same speed. The speeds of both pumps are modulated together, as a unit, to maintain the level setpoint.

c) When the two pumps are running at a minimum speed (operator adjustable, initially 50%), the Lag pump ramps to a stop while the Lead pump continues to have its speed modulated to maintain the level setpoint.

d) If the Lead pump is the only operating pump and it is running at minimum speed and the Biosolids Day Tank level drops below an adjustable low setpoint for an operator-adjustable time delay, the Lead pump is stopped.

d. When in Flow Control Mode, both pumps run and operate as follows:

1) There is one flow transmitter on the discharge of each pump. The flow from Screw Press Feed Pump 1 to Screw Press 1 is monitored by one flow transmitter, and the flow from Screw Press Feed Pump 2 to Screw Press 2 is monitored by another flow transmitter. Control of each pump shall be based on the discharge flow, as measured by the corresponding flow transmitter.

2) A single PID control loop (refer to Control Strategy 7) adjusts the pump's speed to maintain the discharge flow setpoint of each pump.

3) If a pump is "Off", it shall not be started or used in the control scheme.

5. Off-Normal Operation:

a. On loss of signal from the level transmitter when the pumps are in Level Control Mode, the pumps shall switch to SCADA Manual Control.

b. On loss of signal from a flow transmitter when the pumps are in Flow Control Mode, the respective pump shall switch to SCADA Manual Control.

E. Interlocks:

1. Hardwire Interlocks:

a. Screw Press Feed Pumps 1-2:

1) Motor high temperature (reset required).

2) Seal Water Low Flow

2. Software Interlocks:

a. Screw Press Feed Pump 1

1) Low suction pressure at Screw Press Feed Pump 1

2) High discharge pressure at Screw Press Feed Pump 1

3) Screw Press 1 not running (delay as described below to allow for startup)

a) Begin an operator adjustable timer (default is 15 seconds).

b) When the timer expires, interlock the Screw Press Feed Pump 1

b. Screw Press Feed Pump 2

1) Low suction pressure at Screw Press Feed Pump 2

2) High discharge pressure at Screw Press Feed Pump 2

3) Screw Press 2 not running (delay as described below to allow for startup)

a) Begin an operator adjustable timer (default is 15 seconds).

b) When the timer expires, interlock the Screw Press Feed Pump 1

F. Alarms
   1. Monitor and display alarms according to Control Strategy 13 and Control Strategy 14.
   2. Additional Hardwired:
      a. Screw Press Feed Pumps 1-2:
         1) Common fail alarm

End of Control Strategy 21

END OF SECTION

SECTION 40 61 96.22

CONTROL STRATEGY 22 - SCREW PRESSES

A. Reference Drawings:
   1. 95-I-101
   2. 95-I-102

B. Equipment

Equipment Tag	Description
72SCP2620	Screw Press 1
72MIX2610	Screw Press 1 Polymer Mixer
72SCP2720	Screw Press 2
72MIX2710	Screw Press 2 Polymer Mixer

C. System Description
   1. This control strategy is used to cover the networked datapoints, monitoring, and control for the screw presses.
      a. There are two screw presses operating in two parallel trains. Each screw press corresponds to one screw press feed pump, which pumps digested sludge into the screw press. The screw presses remove water from the digested sludge and discharge dewatered biosolids to the conveyance and loading system.
      b. Each screw press runs when the corresponding screw press feed pump is running.
      c. For system functional description and level control of the screw presses, refer to Section 46 76 27 – Screw Press.

D. Control Descriptions
   1. Local Manual Control:
      a. Local manual control of the system can be enabled by setting the system LOCAL/OFF/REMOTE selector switch to LOCAL. While in LOCAL the system is operated locally from the local control panel. Refer to Section 46 76 27 for local control requirements.
      b. Under normal operating conditions, the system is set to REMOTE. This enables SCADA control, as specified in the paragraphs below.
      c. Local controls are limited by all interlocks.
   2. Local Auto Control:
      a. None
   3. SCADA Manual Control:
      a. SCADA Manual control of the system can be enabled by setting the system LOCAL/OFF/REMOTE selector switch to REMOTE and selecting SCADA MANUAL in the HMI.
      b. While in SCADA Manual, an operator can start or stop the system by selecting START or STOP on the HMI.
      c. Refer to Section 46 76 27 for SCADA control requirements.

4. SCADA Auto Control:
    a. SCADA Auto control of the system can be enabled by setting the system LOCAL/OFF/REMOTE selector switch to REMOTE and selecting SCADA AUTO in the HMI.
    b. While in SCADA Auto, the system is operated by SCADA.
        1) Each screw press runs if the corresponding screw press feed pump is running.
        2) If one of the screw press feed pumps stops, begin a safe stop sequence for the corresponding screw press as follows:
            a) When the screw press feed pump stops, begin an operator adjustable timer (default is 300 seconds).
            b) Continue running the screw press until the timer expires.
    c. Refer to Section 46 76 27 for SCADA control requirements.

E. Networked Control and Monitoring
1. At a minimum, provide the following data for monitoring of the control commands for each Screw Press according to Control Strategy 15.
    a. Polymer Mixer Run Command
    b. Solenoid Valve 1 Open Command
    c. Solenoid Valve 2 Open Command
    d. Solenoid Valve 3 Open Command
    e. Solenoid Valve 4 Open Command
    f. Solenoid Valve 5 Open Command
    g. Screw Press Drive Motor Speed Command
    h. Screw Press Drive Motor Run Command
2. At a minimum, provide the following data for monitoring of the system statuses for each Screw Press according to Control Strategy 15.
    a. Polymer Mixer High Level
    b. Polymer Mixer In Remote
    c. Polymer Mixer Run Status
    d. Polymer Mixer Common Fail
    e. Screw Press Inlet Level
    f. Screw Press Emergency Stop
    g. Screw Press Drive Motor Speed
    h. Screw Press Drive Motor In Remote
    i. Screw Press Drive Motor Run Status
    j. Screw Press Drive Motor Common Fail
3. Coordinate with Owner for additional data points required.

F. Interlocks
1. Hardwire Interlocks:
    a. Refer to Section 46 76 27 for system interlocks.
2. Software Interlocks:
    a. Refer to Section 46 76 27 for system interlocks.

b. Screw Press 1-2:
    1) Cake Collection Screw 1 Jam (Low Speed)
    2) Cake Collection Screw 1 not running (delay as described below to allow for startup)
        a) Begin an operator adjustable timer (default is 15 seconds).
        b) When the timer expires, interlock the Screw Presses
    3) (For Schwing) Screw Press Discharge Screw Conveyor 1 Jam
    4) (For Schwing) Screw Press Discharge Screw Conveyor 1 not running (delay as described below to allow for startup)
        a) Begin an operator adjustable timer (default is 15 seconds).
        b) When the timer expires, interlock the Screw Presses

G. Alarms
    1. Hardwired:
        a. Refer to Section 46 76 27 for system alarms.
    2. Network:
        a. Refer to Section 46 76 27 for system alarms.
    3. Derived:
        a. Refer to Section 46 76 27 for system alarms.

End of Control Strategy 22

END OF SECTION

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SECTION 40 61 96.23

CONTROL STRATEGY 23 - CONVEYORS

A. Reference Drawings:
   1. 95-I-104

B. Equipment

Equipment Tag	Description
72CON4201	Cake Collection Screw 1

C. System Description
   1. This control strategy is used to cover the control of the discharge conveyors.
      a. There is one cake collection screw that operates when either of the screw presses are running. The cake collection screw conveys dewatered biosolids to the cake transfer screw or to the biosolids storage (in the case where the cake transfer screw is not running).
      b. For system functional description, refer to Section 41 12 13.16.

D. Control Descriptions
   1. Local Manual Control:
      a. Local manual control of the system can be enabled by setting the system LOCAL/OFF/REMOTE selector switch to LOCAL. While in LOCAL the system is operated locally. Refer to Section 41 12 13.16 for local control requirements.
      b. Under normal operating conditions, the system is set to REMOTE. This enables remote control via SCADA, as specified in the paragraphs below.
      c. Local controls are limited by all interlocks.
   2. Local Auto Control:
      a. None
   3. SCADA Manual Control:
      a. SCADA Manual control of the system can be enabled by setting the system LOCAL/OFF/REMOTE selector switch to REMOTE and selecting SCADA MANUAL in the HMI.
      b. While in SCADA Manual, an operator can start or stop the conveyor by selecting START or STOP on the HMI.
   4. SCADA Auto Control:
      a. SCADA Auto control of the system can be enabled by setting the system LOCAL/OFF/REMOTE selector switch to REMOTE and selecting SCADA AUTO in the HMI.
      b. While in SCADA Auto, the system is operated by SCADA.
         1) If any screw presses are running (as determined by the monitoring specified in Control Strategy 22), the conveyor runs.
         2) If all screw presses stop, begin a safe stop sequence as follows:
            a) When all screw presses stop, begin an operator adjustable timer (default is 120 seconds)
            b) Continue running the conveyor until the timer expires.

E. Interlocks
   1. Hardwire Interlocks:
      a. Emergency Stop Pushbutton activated
      b. Conveyor Motor Torque High
      c. Conveyor Motor Temperature High
      d. Conveyor Jam (Low Speed)
   2. Software Interlocks:
      a. None
   3. Refer to Section 41 12 13.16 for additional interlocks.

F. Alarms
   1. Hardwired:
      a. None.
   2. Network:
      a. None.
   3. Derived:
      a. Fail to Run.

End of Control Strategy 23

END OF SECTION

SECTION 40 61 96.24

CONTROL STRATEGY 24 - CONVEYOR DISCHARGE GATE

A. Reference Drawings:
   1. 95-I-104
   2. 95-I-105

B. Equipment

Equipment Tag	Description
72G4301	Cake Collection Screw 1 Discharge Gate

C. System Description
   1. This control strategy is used to cover the motor actuated open/close gate associated with Cake Collection Screw 1.
   2. The gate is fail close.
   3. The gate opens when the existing Cake Transfer Screw (72M4401) is running and when Cake Collection Screw 1 (72CON4201) is running. Otherwise, the gate fails closed, which directs biosolids to the Biosolids Storage.

D. Control Descriptions
   1. Local Manual Control:
      a. Local manual control of the actuator can be enabled by setting the actuator LOCAL/OFF/REMOTE selector switch to LOCAL. While in LOCAL the gate can be opened and closed at the actuator with an OPEN/CLOSE selector switch which allows the gate to be opened fully or closed fully.
      b. Under normal operating conditions, the actuator is set to REMOTE. This enables SCADA control, as specified in the paragraphs below.
      c. Local controls are limited by all hardwired interlocks.
   2. Local Auto Control:
      a. None
   3. SCADA Manual Control:
      a. SCADA Manual control of the gate can be enabled by setting the system LOCAL/OFF/REMOTE selector switch to REMOTE and selecting SCADA MANUAL in the HMI.
      b. While in SCADA Manual, an operator can fully open or fully close the gate by selecting OPEN or CLOSE on the HMI.
   4. SCADA Auto Control:
      a. SCADA Auto control of the gate can be enabled by setting the system LOCAL/OFF/REMOTE selector switch to REMOTE and selecting SCADA AUTO in the HMI.
      b. While in SCADA Auto, the gate is operated by SCADA.
         1) If Cake Collection Screw 1 (72M4201) is running and the existing Cake Transfer Screw (72M4401) is running, the gate opens.

E. Interlocks and Permissives
    1. Hardwire Interlocks:
        a. None.
    2. Software Interlocks:
        a. Existing Cake Transfer Screw (72M4401) is not running
        b. Cake Collection Screw 1 (72M4201) is not running

F. Alarms
    1. Hardwired:
        a. Refer to Control Strategy 16 for monitoring and alarm conditions.
    2. Network:
        a. None.
    3. Derived:
        a. Refer to Control Strategy 16 for monitoring and alarm conditions.

G. Calculations:
        a. None.

End of Control Strategy 24

END OF SECTION

SECTION 40 61 96.25

CONTROL STRATEGY 25 – TEMPORARY SCREW PRESS

A. Reference Drawings:
   1. 95-IT-101
   2. 95-IT-102

B. Equipment

Equipment Tag	Description
72SCP2620	Screw Press 1
72MIX2610	Screw Press 1 Polymer Mixer
72LCP2601T	Temporary Screw Press Control Panel
78M4499	Temporary Inclined Screw

C. System Description
   1. This control strategy is used to cover the networked datapoints, monitoring, and control for the temporary dewatering system.
      a. The temporary dewatering system is made up of one screw press that will be installed in a temporary location, a polymer mixer, a temporary local control panel, temporary inclined screw conveyor, and associated appurtenances as shown on the contract drawings.
      b. Existing screw press feed pumps will pump digested sludge to the temporary dewatering system. And the existing polymer system will pump polymer to the temporary dewatering system.
      c. The screw press removes water from the digested sludge and discharge dewatered biosolids to the temporary inclined screw.
      d. The temporary inclined screw conveys the dewatered biosolids to the storage bays.

D. Control Descriptions, Interlocks, and Alarms
   1. Refer to Section 40 61 96.22 (Control Description 22) for the operation, interlocks, and alarms of the screw press.
   2. Refer to Section 40 61 96.23 (Control Description 23) for the operation, interlocks, and alarms of the conveyor. In SCADA Auto, the temporary conveyor starts and stops based on the running status of the screw press.

E. Networked Control and Monitoring
   1. Refer to Section 40 61 96.22 (Control Description 22) for the operation of the screw press.
   2. Provide full control and monitoring of the screw press at the temporary screw press control panel (72LCP2601T) using a mirrored HMI that has a network connection to the main screw press control panel (72LCP2601).

End of Control Strategy 25

END OF SECTION

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SECTION 40 63 43

PROGRAMMABLE LOGIC CONTROLLERS

PART 1 GENERAL

1.01 DESCRIPTION

A. Scope

1. This Section specifies requirements for programmable logic controllers (PLC) designed to execute discrete and continuous control logic with high reliability in industrial applications.
2. The Processor (controller), Network Communication modules, I/O (Input/Output) modules, power supplies and appurtenances are specified herein.
3. All PLCs provided for this project shall comply with the requirements of this Section.
4. PLCs provided with equipment specified in Division 46 shall be provided by the Equipment Manufacturer.
5. Provide all PLC hardware as indicated as specified in the PLC Schedule.
6. Enclosures and other panel components are specified in Section 40 67 00.

B. General Requirements

1. General requirements shall be as specified in Sections 40 61 13 and 40 67 00.
2. PLC assemblies provided by Equipment Manufacturers may be provided by firms other than the Systems Integrator.

C. PLC Schedule

PLC No.	Panel No.	Provided By	PLC Type	Testing Required	Spares Required
72PLC0101	72LCP0101	Contractor	ControlLogix	Site Testing	Yes
72PLC2601	72LCP2601	Vendor	CompactLogix	Site Testing	Yes
72PLC2701	72LCP2701	Vendor	CompactLogix	Site Testing	Yes

1.02 QUALITY ASSURANCE

A. References

1. This Section contains references to the following documents or documents listed in Sections 26 05 00, 40 61 13, and 40 67 00. They are a part of this Section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this Section as if referenced directly. In the event of conflict between the requirements of this Section and those of the listed documents, the requirements of this Section shall prevail.
2. Unless otherwise specified, references to documents shall mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid (or on the effective date of the Agreement if there were no Bids).
3. If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued.

4. Where document dates are given in the following listing, references to those documents shall mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, discontinued or replaced.

Reference	Title
IEC 61131-3	Programmable Controllers – Part 3: Programming Languages
NEMA IA 2.2	Programmable Controllers – Equipment Requirements and Tests
NEMA IA 2.3	Programmable Controllers – Programming Languages

1.03 SUBMITTALS

A. The following information shall be provided in accordance with Sections 01 33 00 and 40 61 13. For Contractor provided PLCs, submit under Section 40 67 00. For Equipment Manufacturer provided PLCS, submit under the corresponding Section.

B. General Requirements:
   1. Submit:
      a. 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. A check mark shall denote full compliance with a paragraph as a whole.
      b. If deviations from the Specifications are indicated, and therefore requested by the Contractor, each deviation shall be underlined and denoted by a number in the margin to the right of the identified paragraph, referenced to a detailed written explanation of the reasons for requesting the deviation.
      c. The Owner or Owner's Representative shall be the final authority for determining acceptability of requested deviations. The remaining portions of the paragraph not underlined will signify compliance on the part of the Contractor with the Specifications.
      d. Failure to include a copy of the marked-up Specification Sections, along with justification(s) for any requested deviations to the Specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration.

C. Action Submittal:
   1. Submit marked product data per Section 01 33 00.
      a. PLC
         1) Processor Type
         2) Processor Speed
         3) Memory
      b. I/O Modules
         1) Type
         2) Standard Wiring Diagram
      c. Network Communication modules
         1) For Ethernet and Modbus Protocols

d. PLC Input/Output (I/O) loop diagram drawings.
e. List of spare parts to be provided.

D. Closeout Submittals:
1. Procedures: Section 01 78 23.
2. Operating and maintenance submittals: Section 01 78 23.
3. Operating and maintenance information shall be provided in accordance with Section 01 78 23, including the following for the PLC system:
a. Manufacturer, Representative, and Supplier contact information.
b. Manufacturer instruction manuals shall include only the following as applicable to the PLC system:
1) Safety Precautions.
2) Environmental Conditions.
3) Troubleshooting guides and diagnostic techniques.
4) Component connection diagrams.
5) Removal and replacement instructions.
c. Warranty information.
d. Final reviewed submittal.
e. As-built drawings with record of switch and jumper settings for all components.
f. List of spare parts provided as specified in Part 2.

E. PLC Program:
1. Provide the as-built programmable controller program on a portable drive or digitally, prepared using the software type specified in Part 2. Provide 2 copies. Label as follows:
a. Owner's name, facility name, project name and project number as shown on the drawings.
b. "Application Programs For (equipment and/or PLC name)".
c. Programming software name and revision.
d. Supplier name and program revision date.

F. PLC Input/Output Summary
1. Provide Programmable Logic Controller (PLC) I/O Summary that lists the assigned input/output points and describes the function.

1.04 ENVIRONMENTAL CONDITIONS

A. Per Section 01 11 80

PART 2 PRODUCTS

2.01 GENERAL

A. Manufacturer
   1. The Owner requires the specified Manufacturer to provide the equipment and/or products to be furnished under this Section. The Owner believe the Manufacturer is capable of producing equipment and/or products that will satisfy the requirements of this Section. This statement, however, shall not be construed to mean that the named Manufacturer's standard product will comply with the requirements of this Section. Manufacturers and models shall be as specified for the purpose of compatible and efficient utilization of existing equipment, supplies, and personnel training and experience, no substitutions are permitted.
      a. PLC Hardware: Allen Bradley
      b. PLC Software: Rockwell Studio 5000, provided by Owner

B. Materials
   1. Equipment and/or products shall be new and unused at the time of system assembly.

C. Controller conforming to NEMA IA 2.2, and with required memory and functional capacity to perform specified sequence of operation with scheduled input and output points.
   1. RFI/EMI Susceptibility: MIL STD 461B CS02.
   2. Showering Arc Test: NEMA Pub No ICS2-230.42.
   3. Surge Withstand: ANSI C37.90a.
   4. RFI Immunity: IEC 801-3.
   5. Ground Continuity: IEC 801-5.
   6. Electrostatic Discharge: IEC 801-2.
   7. Electromagnetic Field: IEC 61000-4-3.
   8. Fast transients: IEC 61000-4-4.

2.02 PROGRAMMABLE LOGIC CONTROLLER – CONTROLLOGIX

A. Provide the following components for PLCs that are ControlLogix according to the PLC Schedule in paragraph 1.01 (see PLC Type in the PLC Schedule).

B. Manufacturer:
   1. Allen-Bradley ControlLogix 5580 series (L80 Series).

C. NEMA IA 2.3 and IEC 61131-3 compliant program editor with program written in Ladder Logic, Function Block, or Sequential Function Language. Program to be written using the same type of software as is specified below.

D. Networking Connections: Provide all communication interfaces, network cables, taps, terminators, power supplies, and accessories for a complete operating network.
   1. Ethernet/IP

E. Power Supplies:
   1. Input: Single, 24 Vdc input.
   2. Sized to power all modules mounted in housing including an average module load for any empty housing slots plus 50 percent above that total

F. Processor:
   1. Memory: RAM size shall be provided so that 50% is available after program is tested.
   2. Controller tasks: 32 tasks with 1000 programs/task
   3. Programming languages: Ladder Diagram, Structured Text, Sequential Function Chart
   4. Communication ports: one USB port, and one EtherNet/IP Port
   5. Allen-Bradley Control Logix 1756-L81E or greater.

G. Network Communication Modules:
   1. Ports: RJ-45 port
   2. Communication rate: 10/100 Mbs or greater
   3. Allen-Bradley 1756-EN2TR or approved equal.

H. Input and Output Modules:
   1. Discrete Inputs: 120 Vac, 16 channel.
   2. Discrete Outputs: 120 Vac, 16 channel.
      a. For field devices interfacing with dry contacts, provide a control relay to be installed in the enclosure.
   3. Analog Inputs: 4-20 mAdc, HART, 16 channel.
   4. Analog Outputs: 4-20 mAdc, HART, 8 channel.
   5. Spare Input/Outputs: The greater of a minimum one channel or 15 percent of each type provided per control panel.
   6. I/O Chassis spare slots: Minimum 1 per chassis.
   7. Manufactured I/O Cables for all modules:
      a. By PLC Manufacturer or other electrical component Manufacturer.
      b. Cable pre-attached to connector compatible with I/O module.
      c. Discrete Input:
         1) Cable with one wire for each I/O module terminal, ready for insertion into separate terminal blocks for field connections.
      d. Discrete Output:
         1) Cable with one wire for each I/O module terminal, ready for insertion into separate terminal blocks for field connections.
      e. Analog Input:
         1) Cable with one wire for each I/O module terminal, ready for insertion into separate terminal blocks for field connections.
      f. Analog Output:
         1) Cable with one wire for each I/O module terminal, ready for insertion into separate terminal blocks for field connections.
      g. Verify cable length required prior to ordering.

I. PLC Chassis (Backplane)
   1. Mount the PLC power supply, Processor, Network Communication modules, and I/O modules in a suitable standard PLC backplane.
   2. Provide a blank slot filler for each spare slot.

J. Miscellaneous:
   1. Provide all cables, taps, terminators, power supplies, and accessories for a complete operating PLC system.

2.03 PROGRAMMABLE LOGIC CONTROLLER – COMPACTLOGIX

A. Provide the following components for PLCs that are required to be CompactLogix according to the PLC Schedule in paragraph 1.01 (see PLC Type in the PLC Schedule).

B. Manufacturer:
   1. Allen-Bradley CompactLogix, 5069 Series

C. Networking Connections: Provide all communication interfaces, network cables (fiber and copper), taps, terminators, power supplies, and accessories for a complete operating network.
   1. Ethernet/IP

D. Power Supplies: Integral with Controller

E. Processor:
   1. Power Supply
      a. Mod Power: 24 Vdc
      b. SA Power: 24Vdc
         1) Install 5069-FPD to separate the 24 Vdc and 120 Vac modules.
   2. Memory:
      a. RAM memory size shall be provided so that 50% is available after program is tested.
   3. Controller tasks: 32 tasks with 1000 programs/task
   4. Programming languages: Ladder Diagram, Structured Text, Function Block Diagram, Sequential Function Chart
   5. Built in Communication ports: one USB port, and two Ethernet (RJ-45) Ports
   6. Local I/O Modules: 8 or greater.
   7. Controller compatible with Logix Designer Version 30.00.00.
   8. Allen-Bradley CompactLogix 5069-L306ER or greater.

F. Input and Output Modules:
   1. General: Compact 5000 I/O modules
   2. Discrete Inputs: 120 Vac, 16 channel.
   3. Discrete Outputs: 120 Vac, 16 channel.
      a. For field devices interfacing with dry contacts, provide a control relay to be installed in the enclosure.

4. Analog Inputs: 4-20 mAdc, 24 Vdc, 8 channel.
5. Analog Outputs: 4-20 mAdc, 24 Vdc, 4 channel.
6. Field Power Distributor: 5069-FTD
   a. 120 Vac
   b. Application: To service 120VAC DI and DO Modules
7. Spare Input/Output channels: 20 percent of each type provided per control panel.

G. Miscellaneous:
1. Provide all cables, taps, terminators, power supplies, and accessories for a complete operating PLC system.

2.04 PROGRAMMING SOFTWARE

A. Software capable of programming, monitoring, and controlling the PLCs will be provided by the Owner.
1. Manufacturer:
   a. Allen-Bradley RS Studio 5000, RS Linx, and network module software.

2.05 SPARE PARTS

A. Provide the following spare parts according to the requirements of the PLC Schedule in paragraph 1.01:
1. One of each unique processor card.
2. One for each ten, minimum of one for each unique I/O card.
3. One of each unique power supply.
4. One of each unique pre-fabricated cable.

2.06 CONTROL PANEL FABRICATION

A. Refer to Section 40 67 00.

B. According to shop drawings showing field connections and any terminal block jumpering required according to Section 40 67 00.

C. Terminate all used and spare I/O wiring to terminal blocks.

D. Provide wire labels with “to-from” PLC slot/base, component name, or terminal number. Wire labels shall be identical at each end.

2.07 PRODUCT DATA

A. The following Product Data shall be provided in accordance with Section 01 33 00.

B. Operating and Maintenance Information:
1. Operating and maintenance information shall be provided in accordance with Section 01 78 23, including the following.
   a. Manufacturer, Representative, and Supplier contact information.

b. Manufacturer instruction manuals shall include only the following as applicable to the PLC system:
    1) Safety Precautions.
    2) Environmental Conditions.
    3) Troubleshooting guides and diagnostic techniques.
    4) Component connection diagrams.
    5) Removal and replacement instructions.
c. Warranty information.
d. Final reviewed submittal.
e. As-built drawings with record of switch and jumper settings for all components.
f. List of spare parts provided.

C. PLC Program for Vendor (Equipment Manufacturer) Provided Systems:
1. Provide the as-built programmable controller program on a Flash Drive, prepared using the software type specified in Part 2. Label the flash drive to include:
    a. Owner's name, facility name, project name and project number as shown on the drawings.
    b. "Application Programs For (equipment and/or PLC name)".
    c. Programming software name and revision.
    d. Supplier name and program revision date.
2. Every line of the as-built program shall be annotated with the code's intent and function.
3. Dead code and all other code that has no function shall be removed from the program.

PART 3 EXECUTION

3.01 EXAMINATION

A. Confirm and field verify equipment locations, area classification and available space prior to fabrication.

3.02 INSTALLATION

A. Assemble and install PLC modules according to manufacturer installation instructions.

B. Install PLC components into the enclosure according to Section 40 67 00.

3.03 FIELD INSPECTION AND TESTING

A. Refer to Section 40 67 00.

B. The Contractor shall provide a qualified service representative to perform the following:
1. Inspect the PLC installation including I/O and network systems, hardware configuration and jumper settings.
2. Monitor all PLC system diagnostic indicators, both hardware and software, and certify that the PLC system performance meets or exceeds the Manufacturer's published specifications.

3. Assist in all testing.
    a. Contractor shall provide a minimum of 80 hours of on-site assistance during testing for each PLC I/O rack.
4. Certify in writing to the Owner that the PLC system has been installed and configured in accordance with the Manufacturer's published guidelines. Equipment Manufacturer certification requirements are per the associated equipment Specification.
5. Fault or trouble conditions shall be investigated and resolved by the Contractor to the satisfaction of the PLC supplier.

C. The Equipment Manufacturer of each system containing a PLC shall provide a qualified service representative to perform the following:
1. Inspect the PLC installation including I/O and network systems, hardware configuration and jumper settings.
2. Monitor all PLC system diagnostic indicators, both hardware and software, and certify that the PLC system performance meets or exceeds the Manufacturer's published specifications.
3. Assist in all testing.
    a. Equipment Manufacturers shall provide a minimum of 8 hours of on-site assistance during testing for each equipment assembly.
4. Certify in writing to the Owner that the PLC system has been installed and configured in accordance with the Manufacturer's published guidelines. Equipment Manufacturer certification requirements are per the associated equipment Specification.
5. Fault or trouble conditions shall be investigated and resolved by the Equipment Manufacturers to the satisfaction of the PLC supplier.

3.04 DOCUMENTATION

A. For Equipment Manufacturers, provide the record program.
1. Provide a minimum of 2 flash drives containing copies of the following:
    a. Application software residing in each PLC:
        1) Finalized fully annotated copy of programmed PLC logic in its native format.
            a) Every line of the as-built program shall be annotated with the code's intent and function.
        2) File names shall match the PLC name and include the date of the implementation.
2. Provide a PLC I/O Summary
    a. Provide an exported list on a flash drive of the assigned input/output points for each specified PLC system. The unassigned PLC I/O points shall be tagged as "SPARE".
        1) Coordinate with Section 40 61 93
        2) Final assignments shall be coordinated between the Contractor, the System Integrator, and the Owner during Construction.

END OF SECTION

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SECTION 40 67 00

CONTROL SYSTEM EQUIPMENT PANELS AND RACKS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:

1. Requirements for local control panels, vendor and manufacturer provided panels, contractor provided custom panels, cabinets, and termination cabinets for instrument, control, and communication equipment for the per the Panel Schedule herein and as required by equipment specifications that include control devices, cabinets and the like.
2. Vendor and Manufacturer panel specification sections referenced in the Panel Schedule and specific requirements for those panels. These panels shall meet the applicable requirements of this specification and as referenced in their specific equipment specifications.
3. Requirements for power supply and conditioning equipment required to support the instrumentation and communication systems specified.

B. Control Panel Schedule:

Panel No.	Spec / P&ID	Features * (See Legend)	Enclosure Type	Panel Title
72LC0101	40 67 00, 95-I-100, 95-I-201, 95-I-202, 95-ID-201	C* 1, 3, 5	Contractor shall provide a new subpanel to be installed in the existing enclosure	Digester Area Control Panel
72LCP2601	46 76 27, 95-I-101	V* 1, 2, 3, 5	NEMA-4X	Screw Press 1 Local Control Panel
72LCP2701	46 76 27, 95-I-102	V* 1, 2, 3, 5	NEMA-4X	Screw Press 2 Local Control Panel

FEATURES Legend:

V* - Vendor / Manufacture Panel per equipment specification requirements

C* - Contractor Custom Panel as shown

1. Programmable Logic Controller (PLC) or Remote I/O devices
2. Panel mounted Human Machine Interface (HMI)
3. Hardwired control logic required
4. Windowed outer door and inner door for displays or devices.
5. UPS
6. Fans
7. Heating
8. Air Conditioning
9. Sun/Rain Hood

1.02 RELATED SECTIONS

A. This section contains specific references to the following related sections. Additional related sections may apply that are not specifically listed below.
   1. Section 26 05 00 specifies raceways, conductors, and device requirements.
   2. Section 26 09 16 specifies control device and pilot device requirements.
   3. Section 40 61 21 specifies testing requirements.
   4. Section 40 63 43 specifies PLC requirements.
   5. Division 46 for equipment requirements.

1.03 REFERENCES

A. This Section contains references to the following documents. Those documents are a part of this Section as specified and modified. In the event of conflict between the requirements of this Section and those of the listed documents, the requirements of this Section shall prevail.

B. Unless otherwise specified, references to documents shall mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid (or on the effective date of the Agreement if there was no Bids). If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued. Where document dates are given in the following listing, references to those documents shall mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, discontinued or replaced. In all cases, the effective version of the local building code at the time of Advertisement for Bids or Invitation to Bid shall be considered the building code in effect.

Reference	Title
ANSI/UL 497-1995	Standard for Protectors for Paired Conductor Communications Circuits
EIA RS-310C	Racks, Panels, and Associated Equipment
NEMA 250	Tests for Flammability of Plastic Materials for Parts in Devices and Appliances
NEMA ICS 6	Industrial Control and Systems: Enclosures
NFPA 70	National Electrical Code (NEC)
NFPA 79	Electrical Standard for Industrial Machinery
UL 94	Tests for Flammability of Plastic Materials for Parts in Devices and Appliances
UL 508A	Industrial Control Panels
UL 698A	Industrial Control Panels Relating to Hazardous (Classified) Locations
UL 1012	Power Supplies
UL 1449	UL Standard for Safety for Surge Protective Devices

1.04 ENVIRONMENTAL CONDITIONS

A. Refer to Section 40 61 13.

1.05 ADMINISTRATIVE REQUIREMENTS

A. Coordination
   1. See Section 01 12 16 Work Sequence.

1.06 SUBMITTALS

A. General:
   1. Procedures: Sections 01 33 00 and 40 61 13
   2. A copy of this specification section, and those listed below with addendum updates included, with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements.
      a. A marked copy of specification Section 26 09 16.
      b. A marked copy of specification Section 40 63 43.
   3. Check-marks (✓) shall denote full compliance with a paragraph as a whole. Deviations shall be underlined and denoted by a number in the margin to the right of the identified paragraph. The remaining portions of the paragraph not underlined will signify compliance on the part of the Contractor with the specifications. Include a detailed, written justification for each deviation. Failure to include a copy of the marked-up specification sections, along with justification(s) for any requested deviations to the specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration.
   4. A copy of the contract document Process and Instrumentation diagrams relating to the submitted equipment, with addendum updates that apply to the equipment in this section, marked to show specific changes necessary for the equipment proposed in the submittal. If no changes are required, the drawing or drawings shall be marked "no changes required". Failure to include copies of the relevant drawings with the submittal shall be cause for rejection of the entire submittal with no further review.
   5. Marked copies of contract Process and Instrumentation Diagrams (P&IDs) related to the submitted equipment.
   6. Marked copies of applicable panel drawings related to the submitted equipment.

B. Action Submittals:
   1. Dimensioned drawings:
      a. Exterior panel and layout
      b. Interior devices and layout
   2. Panel assembly drawings including sections showing clearances between face and rear mounted equipment.
   3. Nameplate engraving schedule:
      a. Indicate engraving by line
      b. Character size
      c. Nameplate size
      d. Panel and equipment tag number and description
   4. Wiring drawings:
      a. Schematic diagrams
      b. Internal wiring diagrams

c. Connection diagrams
d. Power and control single line diagrams to comply with NEC Article 409.

5. Heat load calculations for each cabinet based on the highest ambient temperature listed in Section 40 61 13 for the area in which the subject panel will be located.
6. UPS battery uptime calculation
7. Marked product literature of all the enclosure electrical devices and components mounted on or within the control panel.
8. List of miscellaneous items, cables, and spare parts.
9. PLC components according to Section 40 63 43.

C. Closeout Submittals:
1. Procedures:
a. Section 01 78 23.
b. Section 01 99 90: Complete applicable and required forms.
2. Operating and maintenance information shall be provided in accordance with Section 01 78 23, including the following for the control system equipment panels, rack, and associated equipment:
a. Manufacturer, Representative, and Supplier contact information.
b. Manufacturer instruction manuals shall include only the following as applicable to the communication system:
1) Safety Precautions
2) Environmental Conditions
3) Troubleshooting guides and diagnostic techniques
4) Component connection diagrams
5) Removal and replacement instructions
c. Warranty information.
d. Final reviewed action submittal.
e. As-built drawings with record of configuration, switch, and jumper settings for all components.
3. PLC Closeout Submittal according to Section 40 63 43 – Programmable Logic Controllers.
4. Test results as specified in Section 40 61 21.

1.07 QUALITY ASSURANCE

A. Panels shall be fabricated and labeled by a Underwriters Laboratory (UL) or other NRTL recognized facility.

B. Listed Products:
1. Provide UL listed equipment and components. Listed for the application.
2. Provide factory applied UL 508A or 698A labels on control panels. Where intrinsic safety barriers are used within a control panel, provide UL 698A factory applied label as required by UL.
3. Label control panels in accordance with NEC Article 409.

4. Cost to retrofit the panel as specified shall be borne by the panel supplier. Corrections or modifications to UL 508A/698A Industrial Control Panels shall be transported to the panel supplier's facility for corrections, testing, relabeling and inspection.
5. Field modifications require a UL inspector site inspection for approval of panel corrections and to re-label the panel after the field modifications are completed.

1.08 DELIVERY, STORAGE AND HANDLING

A. Procedures: Section 01 66 00

PART 2 PRODUCTS

2.01 FABRICATION

A. General:
   1. Design panels for the seismic requirements in Section 40 61 13. Brace equipment and devices to prevent damage from specified forces. Equipment panels shall be capable of operation following a disturbance.
   2. Identify face-mounted instruments with tag number and equipment description nameplates. Mount instruments for access to components and ease of removal. Blank off cutouts for future equipment with suitable covers.
   3. Install face-mounted equipment flush or semi-flush with flat-black escutcheons. Face-mounted instruments that are more than 6 inches deep, weigh more than 10 pounds, or exert more than a 4 ft-lb moment force on the face of the panel shall be supported underneath at the rear by a 1-inch x 1/8-inch thick steel angle.
   4. Provided floor stands for panels less than 60 inches high to raise the top of the panel to 60 inches above the floor or work platform. Panels that weigh less than 100 pounds may be wall mounted.
   5. Panels with specified requirements including stainless steel or aluminum mounting requirements that are indicated on the project drawings or on the project details take precedence over the panel types or panel features indicated herein.
   6. Provide the instrument, control, and monitoring features indicated on the Process and Instrumentation Diagram(s) (P&ID) and electrical drawings
   7. Provide panels with programmable logic controllers (PLC) and human machine interface (HMI) units as indicated in the Panel Schedule.

B. Panel Design:
   1. General:
      a. Panel networking hardware and control software are specified in other Sections within Division 40.
      b. Provide finger safe devices.
   2. Control Power Distribution:
      a. Panel containing 120-volt powered equipment shall use the din-rail power distribution method with fuses and blown fuse indication. Power is restricted to 120 Vac and 24 Vdc.
   3. Panels containing voltages greater than 480 Vac shall be separated from the control section by physical barrier.

4. Power Supplies:
    a. Panel containing direct current powered instruments or serving as the termination point for transmission loop powered field instruments shall contain direct current power supply system as specified herein.
5. Electrical Control Devices:
    a. Pushbuttons, indicating lights, relays, and similar equipment located in panels specified in this section shall comply with this specification.
6. Uninterruptible Power Supplies:
    a. Panel mounted 120 Vac input and 120 Vac output are specified herein.
    b. Provide mounting and support for UPS in panels. UPS shall not be installed on the bottom of cabinets.

C. Panel Layout:
1. Provide 10 percent spare contiguous sub-panel area for future expansion.
2. Provide minimum of 10 percent spare terminal blocks, with a minimum of 10 analog, discrete, and power.
3. Provide minimum of 12 inches clear space from the bottom of the panel to the bottom of the subpanel.
4. Separation between the power components (over 120Vac) and the control / instrument components (120Vac and less) by locating the power components and the control / instrument components in separate sections of the cabinet enclosure.
5. Power cabinet section and the control / instrument cabinet section with separate door handles.
6. Separation between the power components and the control / instrument components using barriers.
7. External lockable circuit breaker handle for the main panel disconnect.
8. Individual power and control components with internal circuit breakers, as required.
9. Motor controllers, as required by the equipment specifications.
10. Displays with door-in-door construction accessible by opening the cabinet outer door.
11. Face-mounted equipment flush or semi-flush with flat-black escutcheons.
12. Panel tops of wall-mounted panels: mounted at the same elevation.
13. Panel inner door contains a copy of the record elementary and wiring diagrams, or reference as allowed per NEC Article 409.
14. Panel inner door contains a drawing holder.
15. Panel drawings enclosed in a transparent, protective jacket.

D. Enclosures:
1. Panel enclosures shall comply with the requirements of NEC Article 409 and NEMA 250.
2. Manufacturer:
    a. Hoffmann Enclosures, Inc.
    b. Saginaw
    c. Rittal.
    d. Approved equal.
3. Protection Coatings and Finish: See paragraph 2.03 herein.

2.02 ENVIRONMENTAL CONTROL (AS REQUIRED)

A. Environmental controls shall be provided as required (see Panel Schedule) to maintain the environmental ratings of the enclosed components and shall maintain the NEMA enclosure rating as required by its location.

B. Provide heat load calculations as described in paragraph 1.06

C. Heating: Panels located in unconditioned areas or outdoors shall be provided with thermostatically controlled space heaters as required to maintain the panel temperature 10 degrees F above ambient to prevent condensation within the panel. Space heaters with surface temperatures that exceed 120 degrees F require an expanded metal guard.

D. Ventilation: Fans shall be equipped with UL-approved washable filters and provide at least 240 cubic feet per minute (CFM). Fans shall be thermostatically controlled. Noise level at 3 feet from exterior wall and 30 degrees off axis shall not exceed 60 NC units.

E. Thermostats shall be Hoffman temperature controller or equal.

F. Air Conditioning: Systems shall be closed loop cooling systems that do not exchange cabinet interior air with ambient air.
   1. The cooling system shall be either a closed glycol loop heat exchange system or a CFC-free refrigeration system as required for heat load and ambient temperature conditions.
   2. Panel air conditioner coils shall be Heresite, or equal coated and protected from corrosion.

2.03 PROTECTION COATING AND FINISH

A. Panels located outdoors or located in corrosive areas shall be bottom coated with waterproof coatings.

2.04 NAMEPLATES

A. External door-mounted components and the panel description shall be identified with plastic nameplates. Machine embossed metallic adhesive labels shall identify tag number of instruments inside panels. Nameplates shall be attached to panel surfaces, not to instruments.

B. The machine engraved laminated white phenolic nameplates with black lettering shall be provided for panel-mounted equipment. Nameplate engraving shall include the instrument tag number and description in 3/32-inch minimum size lettering.

C. The machine embossed metallic adhesive labels shall identify tag number of instruments inside panels. Nameplates shall be attached to panel surfaces, not to instruments.

D. The nameplates shall be attached to the panel with a minimum of two self-tapping 316 stainless steel screws. Provide NEMA-4X sealing washers for nameplates for NEMA-4X panels.

E. The nameplate wording may be changed without additional cost or time prior to commencement of engraving. Submit nameplate legend with the panel submittal.

2.05 PANEL FEATURES

A. Panel Wiring:
   1. Panel control wiring: Single conductor stranded copper NEC rated Type MTW No. 16 AWG minimum(rated 10 A per NFPA 79, Table 12.5.1), with an exception for factory supplied PLC wiring harnesses that are U.L. approved.
   2. Panel instrument wiring: Twisted No. 18 AWG shielded pair or triad conductors.
   3. Panel power wiring: Conductors specified in Division 26 and meet the NEC requirements for power including phase, grounded, and grounding conductors.
   4. Wiring shall be supported independently of terminations by lacing to panel support structure or by slotted flame retardant plastic wiring channels.
   5. Wiring channels shall comply with UL 94, Type V.
   6. Plastic wireway with covers shall be used to route groups of wires. Wireway fill shall be sized to provide 50% maximum fill.
   7. Plastic spiral wrap shall be used for exposed wires. Wires that cross door hinges shall be enclosed in plastic spiral wrap.

B. Conductor Identification:
   1. Wiring shall be tagged at every termination with machine printed plastic sleeves or pre-printed self-sticking labels as manufactured by W.H. Brady, 3M, or approved equal. No hand-written labels are permitted.
   2. Three-part wire numbers for instrument and control panel internal conductors:
      a. Part-1: Prefix of the wire number shall be the instrument loop number or equipment tag number.
      b. Part-2: Code letter and wire colors per the following tables.
      c. Part-3: Number that identifies individual circuit conductor Terminal Number.

Code	120 Vac Conductor	Color
L	Power	Black
C	Control	Red
N	Neutral	White
PG	Ground	Green

Code	V dc Conductor	Color
PS	24 Vdc Power	Blue
N	24 Vdc Neutral	White with Blue
S+	Signal (+)	Black
SG	Signal Ground	White
EG	Equipment Ground	Green
FV	Panel Foreign Voltage	Yellow
IS	Intrinsically Safe	Light Blue

C. Conductor Installation And Protection:
   1. Power and control wiring shall be carried in covered channels separate from low voltage signal circuits. An interior steel barrier shall be provided between AC control devices and the electronic equipment.

2. Terminal blocks shall be strap screw type rated for 600 volts, finger safe.
    a. No more than two connections shall be made to one terminal.
    b. Each terminal strip shall have a unique identifying alphanumeric code at one end and a vinyl-marking strip running the entire length of the terminal strip with a unique number for each terminal. Numbers shall be machine printed and 1/8 inch high.
    c. Terminal blocks shall be colored in coordination with control wiring.
    d. Terminal blocks shall be:
        1) Allen-Bradley 1492-HM1 600 V 30-amperes, finger-safe terminal block.
        2) Phoenix Contact, Weidmuller, or equal products.

D. Field Wiring:
1. Field wiring shall be connected to separate dedicated terminal blocks in a dedicated section of the panel where the field cables enter the panel. Provide a dedicated raceway on the field side of the terminal block for field wiring use only.

E. Fuse And Fuse Holders:
1. Fuses for 120 Vac circuits shall have a minimum of 12,000-amperes interrupting capacity and blown fuse indicators.
2. Fuses for 24 Vdc circuits shall be fast acting glass tube type rated 1/10 amp for 4-20 mA loops.
3. Fuses for 24 Vdc circuits shall be 1/2 amp for the power supply to individual instruments.
4. Fuse holders shall be tip-out or draw-out, finger safe type.
5. Provide Bussmann, Phoenix Contact or equal products.

F. Power Distribution:
1. Panel power source: According to contract drawings
2. Provide a 480 Vac or 240 Vac, or 208 Vac circuit for air conditioning load as required. Provide the power transformer required for the air conditioning load.
3. Panel Power Distribution (120Vac):
    a. Provide control power transformers, as required for the load.
    b. Provide a 120 Vac circuit for the panel light, receptacle, heating, fan, or heat exchanger load as required.
        1) These items shall not be connected to the load side of the UPS.
    c. Provide a 120Vac circuit for UPS connection.
    d. Connect the following to the load side of the UPS:
        1) Any control power for DI points and DO points.
        2) Any power for field instruments
4. Uninterruptable Power Supply (UPS):
    a. Provide UPS with an integral UPS maintenance bypass switch according to the Panel Power Distribution requirements above.
5. Panel Power Distribution (24Vdc):
    a. Provide direct current power supplies, as required for the load.

b. Provide dual 24Vdc power supplies with a redundancy module for all control devices (PLC), network devices (Switch), and loop powered devices as required.
    1) Connect the input of one of the 24Vdc power supplies to the utility (non-UPS) 120Vac distribution system and connect the input of one of the 24Vdc power supplies to the load side of the UPS.
    2) Connect the outputs of the 24Vdc power supplies to the redundancy module.
c. Provide distribution for all control devices requiring 24Vdc.

G. Accessories:
1. Panels greater than 24" high x 24" wide shall include GFCI convenience receptacles and LED utility lights.
    a. Receptacles and utility lights shall not be powered by the UPS, where included.
2. Provide Print/Data pocket internal to the enclosure.

H. Fail-Safe Wiring:
1. Fail-safe wiring of control relay or other on/off device or instrument provides the condition that will occur upon loss-of-power or internal failure in the device such that the relay is de-energized in the failure or loss-of-power condition such that the control relay contact operation provides for equipment failing in a safe mode.

2.06 ALARM AND TROUBLE DETECTION

A. Alarm and trouble output:
1. The equipment control system shall incorporate a normally open, circuit to open upon an alarm or trouble condition for of the power supply components.
2. The normally open alarm contacts of the power supply, power supply redundancy module, UPS, and Surge Protective Devices, shall be wired in series and monitored by using a Discrete Input channel and indicating light.

2.07 CONTROL DEVICES

A. Control devices shall comply with Section 26 09 16.

2.08 INDICATING LIGHTS

A. Indicating lights shall be equipped with colored lenses as specified in Section 26 09 16.

B. Provide indicating lights on PLC panels for the following conditions:
1. CONTROL POWER NORMAL (white indicator)
    a. Illuminate when the power supply, power supply redundancy module, UPS, and Surge Protective Devices are in normal state.
2. CONTROL POWER ALARM (amber indicator)
    a. Illuminate when the power supply, power supply redundancy module, UPS, and Surge Protective Devices are in alarm.

2.09 POWER SUPPLY AND CONDITIONING EQUIPMENT

A. Except for power supply units which form an integral part of an individual piece of equipment, all power supply and conditioning equipment shall comply with UL 1012 and shall be approved by UL, CSA, or FM for the application.

B. All power supply equipment shall be provided in redundant configurations such that failure of a single unit will not disable all or any part of the instrumentation and communication systems.

C. Direct-Current Power Supplies:
   1. Redundancy step-diode isolation
      a. Redundancy module shall be provided for redundant direct current supply units. The power supply negative output terminal shall be grounded.
      b. Manufacturer: Phoenix Contact, Model STEP-DIODE.
      c. Provide dry contact for failure alarm. Dry contact to be wired as an input to the as described in Paragraph 2.06
   2. Nominal 24-volt direct-current instrumentation and control power supply:
      a. Convection-cooled linear type or switching type.
      b. Line regulation: 0.4 percent for line variations from 105 to 132 volts
      c. Load regulation: 0.4 percent for load variations from 0 to full load.
      d. Ripple and noise: Not exceed 100 mV peak-to-peak.
      e. Hold-up time at maximum load: Not less than 16 milliseconds.
      f. Continuous duty from 0 to 50 degrees C at rated load.
      g. Output electronically current limited.
      h. Over-voltage crowbar shutdown.
      i. Output voltage:
         1) Rated 28 Vdc
         2) Adjustable plus or minus 5 percent
         3) Set to provide 26.4 volts to the panel direct current bus.
      j. Power Supply Manufacturer: Phoenix Contact, or equal.
      k. Provide dry contact for failure alarm. Dry contact to be wired as an input to the as described in Paragraph 2.06

D. Uninterruptible Power System (UPS):
   1. The UPS shall be on-line, computer-grade, double conversion type, with electrical isolation including output neutral. UPS shall be packaged for panel enclosure mounting using a back-panel bracket or holder:
      a. Nominal input voltage: 120Vac.
      b. Nominal output voltage: 120Vac.
      c. Include dry contact to indicate device alarm or failure.
   2. The online UPS system shall be provided with sealed no maintenance batteries, sized to provide full capacity backup power for 15 minute minimum at connected load with integral battery charger.
      a. Provide UPS runtime calculations according to paragraph 1.06.

3. The panel supplier shall calculate the required kVA rating at 150 percent of connected load. Submit load calculations, schematic diagrams, and wiring connection diagrams. Provide battery cabling and other required cabling for a complete system.
4. The UPS shall be mounted within the panel on a pedestal or tray with stainless-steel legs to provide space for wire entry and passage.
5. The UPS shall be configured with a maintenance bypass switch to allow ease of removal from the panel; to allow the panel to operate on utility power.
6. Uninterruptible power supply systems shall be as manufactured by Eaton, Schneider Electric, APC, or approved equal.

2.10 SURGE PROTECTION

A. General: Surge protection shall be provided to protect the electronic instrumentation systems from surges propagating along the signal and power supply lines. The protection systems shall be such that the protection level shall not interfere with normal operation, but shall be lower than the instrument surge withstand level, be maintenance free, and self restoring. Signals originating from instruments mounted outside the building where the control panel is located shall include surge protection at the panel and at the transmitter, for two-wire and four-wire instruments.
   1. Provide lightning and surge protection devices at all antennas, as well as signal lines, communication networks, and power feeds for all lines that originate or are routed outside a building on any part of the existing or proposed circuits.
   2. Lightning and surge protection devices shall provide full protection from line to line and from line to ground. Units shall be DIN-rail mounted, rated for a minimum of 10kA maximum surge current and voltage suitable for the type of circuit being protected. Reaction time shall be on the order of nanoseconds.

B. AC power lines shall comply with all requirements of UL1449 with listed devices having a minimum 18kA surge protection and RFI filtering.

C. Surge protectors shall be removable without changing the impedance of the circuit.

D. Surge protectors product manufactures shall be:
   1. Schneider Electric (Edco/ASCO)
   2. Phoenix Contact
   3. Weidmuller
   4. Mersen
   5. Or approved equal.

E. For analog signal lines use ANSI/UL497 listed device with minimum 15kA protection SD Series, as manufactured by MTL, or approved equal.

F. For Ethernet BaseT communications use UL497A & UL497B listed ZoneBarrier Model ZB24540IE, Category 6 Universal LAN Protector as manufactured by MTL, or approved equal.

G. Provide Type 1 surge protective devices, per NEC Article 242, at the power feed to the panel. Surge Protective Devices (SPD) shall be designed to provide transient voltage protection for a service entrance panelboard. SPD units shall comply with UL 1449, and shall be listed for such use. SPD units shall be rated for the voltage and phase service of the panel at 120 kA per phase. SPD units shall have a built-in diagnostic package with flashing trouble indicator, a display for the status of each phase, and a counter and display to indicate the number of surges that have caused the device to operate.
   1. SPD units shall be Eaton Clipper Power System, Visor Series, Circuit Components Inc, or approved Equal.
   2. Include dry contact to indicate device alarm or failure.

H. Surge arrestors and capacitors shall be provided on the primary winding of isolation transformers supplying power to solid state systems. Surge protectors shall be mounted in a separate enclosure adjacent to the transformer and the incoming line is passed through this enclosure. Surge arrestors shall be General Electric 9L15EC or equal. Surge capacitors shall be General Electric 9L18B, or equal.

2.11 PANEL GROUNDING

A. Each panel shall be provided with two copper ground bars.
   1. One bar (NEC required) shall be bonded to the panel or panel frame or back-plate and to the facility grounding system.
   2. Second (signal) ground bar shall be mounted on insulated stand-offs and shall be bonded to the panel ground bar only at one point.

B. Signal circuits, signal cable shields, and low-voltage DC power supply commons shall be bonded to the signal ground bar.

C. Field analog wiring shields shall only be grounded at the signal ground bar. Test to verify that single ground point at panel signal ground bar.

D. Surge protectors and separately derived AC power supplies shall be bonded to the frame ground bar.

E. Panels exceeding 36-inches width shall contain ground bars shall be 1/4- by 1-inch copper bars extending the entire length of the panel interior at the bottom of the panel.

2.12 PROGRAMMABLE LOGIC CONTROLLERS

A. Provide Programmable Logic Controllers (PLCs) in accordance with Section 40 63 43.

2.13 HUMAN MACHINE INTERFACE (HMI)

A. Provide HMI as required by PLC Schedule in paragraph 1.01.

B. HMI:
   1. Display: 12” analog resistive multi-touch display, TFT color
   2. Brightness: 300 cd/m^2
   3. Power 24 VDC
   4. Communications: Ethernet/IP via dual 10/100Base-T Rj-45 port

5. Rating: Provide HMI with NEMA rating to maintain the NEMA rating of enclosure
6. Manufacturer:
    a. Rockwell/Allen Bradley Panelview 5000
        1) Software: Studio 5000 View Designer
    b. Approved equal

2.14 INDUSTRIAL MANAGED NETWORK SWITCH

A. Network Ethernet switch to provide connectivity between the control system network components. Provide the switch with the following minimum features:
    1. Fan-less steel industrial-strength enclosure
    2. DIN rail mounted
    3. Minimum of six (6) shielded RJ-45 ports with auto-negotiation and auto-MDI/MDIX
    4. Link Standby redundancy
    5. Bandwidth control
    6. MODBUS TCP support
    7. 10/100 Mbps operation
    8. Dry contact for local network health monitoring, or generation of alarm
    9. Switch shall have a minimum of 2 spare ports after connection of all network components
    10. Manufacturers:
        a. Cisco Catalyst IE3100
        b. Allen Bradley Stratix 5200
        c. Hirschmann BOBCAT series
        d. Or approved equal

2.15 PANEL DRAWING PROTECTION

A. Provide wiring diagrams in accordance with Section 01 33 00. Provide a panel-wiring diagram and schematic for each panel in a plastic bag or plastic container to avoid water damage and aging.

2.16 SPARE PARTS

A. The following spare parts shall be provided:
    1. Ten each of each type of light bulb used in the panels.
    2. Five each of each type and rating of fuse used in the panels.
    3. Five each of each type primary protector surge suppressor used in the panels.
    4. Two each of each type of surge protective device used in the panels.

PART 3 EXECUTION

3.01 EXAMINATION

A. Confirm and field verify equipment locations, area classification and available space prior to fabrication.

B. Factory Testing
   1. Assemble, interconnected, and functionally test control panels and devices at the assembly shop prior to shipment.
   2. The Owner and Engineer shall have the option of witnessing the functional shop test. The Contractor shall notify the Owner and Engineer at least three (3) weeks in advance prior of the scheduled functional shop test.

C. Complete assembly and test control panels prior to shipment. This includes specified labeling for complete assembly, devices, components and wiring.

D. Provide panels with the Record As-built schematic, connection, and interconnection diagrams mounted behind holder on the inside of the door.

E. Verify that all panels have been labeled with Arc Flash warning labels per NEC 110.16. Provide labels, with Arc Flash protection boundary and PPE levels.

F. Network connected equipment IP addressing and address ranges shall be provided by the SI in coordination with the Owner. Vendor and manufacturer provided equipment shall program IP addresses as directed by the SI.

G. Vendor and manufacturer provided control systems and control panels shall be coordinated with the Systems Integrator to provide a continuous list of data points required for data to monitor and control processes and systems as shown on the drawings from the plant- wide control system (SCADA).

3.02 PREPARATION

A. Floor mounted cabinets shall be mounted and shimmed to precise alignment so doors operate without binding. The interior of conduits entering panels shall be sealed per Section 26 05 33.

B. Floor-mounted panels except in dry control rooms or electrical equipment rooms shall be mounted on 3-1/2-inch minimum height concrete pads or grouted bases as specified.

C. Coating shall be provided for outdoor panels in contact on concrete. Field panels and cabinets shall be mounted in compliance with Section 40 61 13.

D. Cabinets with HMIs shall be mounted so the OIT is at normal eye level (approximately 60-65” AFF). HMIs on floor mounted cabinets shall be installed on the cabinet door at eye level.

3.03 INSTALLATION

A. Control panels supported directly by concrete or concrete block walls shall be spaced out not less than 5/8 inch by framing channel between instrument and wall. Sills shall be leveled so panel structures will not be distorted. Panels shall be shimmed to precise alignment so doors operate without binding and mounted where shock or vibration will impair its operation.

B. Support systems shall not be attached to handrails, process piping or mechanical equipment. Control panels supported directly by concrete or concrete block walls shall be spaced out from the wall to provide for air circulation around the panels.

C. Steel used for support of equipment shall be 316 stainless steel. Support systems including panels shall be designed to prevent deformation greater than 1/8 inch under the attached equipment load and an external load of 200 pounds in any direction.

D. Center-line of wall-mounted panels shall be 48 inches above the floor.

E. Panel Power Supply
   1. Power supply and conditioning equipment shall be mounted and connected in compliance with the manufacturer's instructions.
   2. Line side disconnect switches shall be provided for power supply and conditioning equipment. Line and load side overcurrent protection shall be provided for power supply and conditioning equipment in compliance with NFPA 70. Disconnect switches shall comply with Section 26 09 16.
   3. Small power supply and conditioning equipment may be mounted in the panel served. Larger units shall be mounted adjacent to the equipment served. Where unconditioned power is brought into control panels, it shall be enclosed in metallic raceways within the panel.
   4. Power supply and conditioning equipment larger than 5 kVA load capacity supported from surfaces other than concrete shall be provided with sound isolators.
   5. Final raceway connections shall be in compliance with Division 26.
   6. Raceway connections and penetrations should enter the bottom of outdoor mounted panels.

3.04 REPAIR/RESTORATION

A. Defective or damaged components shall be removed and replaced.

B. Control panels, equipment and racks shall be cleaned, properly closed and secured prior to acceptance.

3.05 FIELD QUALITY CONTROL

A. Field test and verify the following for Instrument and Control Panels:
   1. Control circuits grounded with one terminal of each load device connected to the grounded conductor.
   2. Control contacts installed in the ungrounded side of the circuit.
   3. Panel signal and control wiring separated and installed in separate wireways with barriers between the power wiring and the signal and control wiring.
   4. Barriers between the power wiring and the signal and control wiring.
   5. Connected to the plant grounding system, as specified.
   6. Inner door contains a copy of the Record elementary and wiring diagrams, in a protected drawing holder. Drawings shall be enclosed in a transparent, protective jacket.
   7. Panel Functions as specified.

8. Mounted with stainless steel Unistrut, fittings, and fasteners.
9. Tested in accordance with Section 26 08 00 and Section 40 61 21.

3.06 SYSTEMS START UP

A. Procedures: Section 01 45 23 and 01 79 00.

B. Coordination with Division 26 for supply, energizing, lockout and tagout procedures during startup and commissioning.

C. Coordinate with associated and applicable equipment and systems that are monitored and/or controlled. Systems shall be tested with equipment as specified to confirm operational functionality and start up completion.

D. Provide field testing as specified herein.

E. Operational testing and commissioning shall be performed and documented as specified and required by Section 01 91 00 and 01 99 90.

END OF SECTION

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SECTION 40 70 93

PROCESS CONTROL SYSTEM INSTRUMENT LIST

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Instrument List for instruments furnished or installed under Sections 40 71 00 through 40 75 00.

B. Related sections:
   1. Section 40 61 13 – Process Control System General Provisions
   2. Section 40 61 21 – Process Control System Testing

1.02 SUBMITTALS

A. Procedures: Section 01 33 00.

B. PCS submittal requirements: Section 40 61 13.

C. Action Submittal:
   1. Submit updated schedule with field instrumentation submittal to match equipment being provided.
      a. Include Manufacturer and Model information.

PART 2 NOT USED

PART 3 EXECUTION

3.01 EXAMINATION

A. Instruments furnished by others or existing.
   1. Listed equipment furnished under other contracts are integral parts of the instrumentation systems specified under this contract and listed in the Instrument List.
   2. Inspect items to verify operation and integration requirements.
   3. Provide wiring, testing, and commissioning services for the listed equipment. Notify the Construction Manager where equipment fails to provide the required function.

3.02 INSTALLATION

A. Refer to Section 40 61 13 for requirements.

3.03 FIELD QUALITY CONTROL

A. Refer to Section 40 61 21 for requirements.

B. Maintain a copy of the complete Instrument List with modifications during construction in Excel format. Provide a copy of the latest version to the Engineer and Owner upon request.

3.04 ATTACHMENTS

A. Appendix A – Process Control System Instrument List
   1. Description of headings in Process Control System Instrument List.

Instrument Field or Heading	Comment or Description
Instrument Tag Number	See P&ID sheet legend
Device Function	Provides the functional description of the instrument
Supplied by	Indicates the party responsible for supplying (furnishing) the instrument. Installation and Integration is the responsibility of the contractor.
Size or Connection	Provides the application data relative to sizing the instrument; flow tube diameter, probe length, associated pipe sizes, etc.
Lower Operating Range	Provides the minimum normal process input
Upper Operating Range	Provides the maximum normal process input
Switch Setpoint	For discrete instruments, setpoint indicates the process limit where change of state occurs.
Power Requirements	Loop Powered, 120-volt, 24-volt, internal battery, etc.
P&ID Number	Contract drawing number
Specification Number	Specification under which device is provided or specified.
InstruSpec	InstruSpec type or other name within specification
Installation Detail Number	Installation detail number if provided.
Comments	Provides the features, interlocks, and information applicable to the instrument, analyzer, or device. Describes special installation instructions, area classifications, modifiers to standard instrument specs, Owner-supplied, existing, accessories, signal surge protection, options, etc.

END OF SECTION

APPENDIX A – PROCESS CONTROL SYSTEM INSTRUMENT LIST

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APPENDIX A
PROCESS CONTROL SYSTEM INSTRUMENT LIST

Instrument Tag Number	Device Function	Supplied By	Size or Connection	Lower Operating Range	Upper Operating Range	Switch Setpoint	Power Requirements	P&ID Number	Specification Number	InstruSpec Number	Installation Detail Number	Comments
72-LIT-0101	Biosolids Day Tank Level	Contractor	4" Flange	0 ft	33 ft	NA	Loop Power	95-I-100	40 72 00	LRNC	I21009	Install on existing stand pipe.
72-PSL-0301	Screw Press 1 Feed Pump Inlet Low Pressure Switch	Contractor	1/2" NPT	NA	NA	2 PSIG	NA	95-I-100	40 73 00	PS	I34001	
72-FSL-0301	Screw Press 1 Feed Pump Seal Water	Contractor	1/2" NPT	NA	NA	1 GPM	NA	95-I-100	40 71 00	FPS	NA	
72-PI-0301A	Screw Press 1 Feed Pump Inlet Pressure Indicator	Contractor	1/2" NPT	0 PSIG	15 PSIG	NA	NA	95-I-100	40 73 00	PG	I34001	
72-TSH-0301A	Screw Press 1 Feed Pump Motor High Temperature Switch	Vendor	By Vendor	NA	NA	By Vendor	NA	95-I-100	43 24 51	NA	NA	
72-TSH-0301B	Screw Press 1 Feed Pump Rotor Stator High Temperature Switch	Vendor	By Vendor	NA	NA	By Vendor	NA	95-I-100	43 24 51	NA	NA	
72-PSH-0301	Screw Press 1 Feed Pump Outlet High Pressure Switch	Contractor	1/2" NPT	NA	NA	100 PSIG	NA	95-I-100	40 73 00	PS	I34001	
72-PI-0301B	Screw Press 1 Feed Pump Outlet Pressure Indicator	Contractor	1/2" NPT	0 PSIG	100 PSIG	NA	NA	95-I-100	40 73 00	PG	I34001	
72-PSL-0302	Screw Press 2 Feed Pump Inlet Low Pressure Switch	Contractor	1/2" NPT	NA	NA	2 PSIG	NA	95-I-100	40 73 00	PS	I34001	
72-FSL-0302	Screw Press 2 Feed Pump Seal Water	Contractor	1/2" NPT	NA	NA	1 GPM	NA	95-I-100	40 71 00	FPS	NA	
72-PI-0302A	Screw Press 2 Feed Pump Inlet Pressure Indicator	Contractor	1/2" NPT	0 PSIG	15 PSIG	NA	NA	95-I-100	40 73 00	PG	I34001	
72-TSH-0302A	Screw Press 2 Feed Pump Motor High Temperature Switch	Vendor	By Vendor	NA	NA	By Vendor	NA	95-I-100	43 24 51	NA	NA	
72-TSH-0302B	Screw Press 2 Feed Pump Rotor Stator High Temperature Switch	Vendor	By Vendor	NA	NA	By Vendor	NA	95-I-100	43 24 51	NA	NA	
72-PSH-0302	Screw Press 2 Feed Pump Outlet High Pressure Switch	Contractor	1/2" NPT	NA	NA	100 PSIG	NA	95-I-100	40 73 00	PS	I34001	
72-PI-0302B	Screw Press 2 Feed Pump Outlet Pressure Indicator	Contractor	1/2" NPT	0 PSIG	100 PSIG	NA	NA	95-I-100	40 73 00	PG	I34001	
72-AIT-2605	Screw Press 1 Inlet TSS	Contractor	6" Flange	0 %	5%	NA	120 VAC	95-I-101	40 75 00	SM	NA	Provide Flushing Port
72-AIT-2705	Screw Press 2 Inlet TSS	Contractor	6" Flange	0 %	5%	NA	120 VAC	95-I-102	40 75 00	SM	NA	Provide Flushing Port
72-AIT-2730	Screw Press Combined Filtrate TSS	Contractor	Vendor Provided Sampling Valve	0 %	0.5%	NA	240 VAC	95-I-102	40 75 00	SO	NA	
72-HS-4201B	Cake Collection Screw 1 Emergency Stop Pull Cord	Vendor	NA	NA	NA	NA	NA	95-I-104		NA	NA	
72-SSL-4201	Cake Collection Screw 1 Low Speed Switch	Vendor	By Vendor	By Vendor	By Vendor	By Vendor	120 VAC	95-I-104		NA	NA	
72-TSH-4201	Cake Collection Screw 1 Motor High Torque	Vendor	By Vendor	By Vendor	By Vendor	By Vendor	NA	95-I-104		NA	NA	
72-NSH-4201	Cake Collection Screw 1 Motor High Temperature	Vendor	By Vendor	By Vendor	By Vendor	By Vendor	NA	95-I-104		NA	NA	

APPENDIX A
PROCESS CONTROL SYSTEM INSTRUMENT LIST

Instrument Tag Number	Device Function	Supplied By	Size or Connection	Lower Operating Range	Upper Operating Range	Switch Setpoint	Power Requirements	P&ID Number	Specification Number	InstruSpec Number	Installation Detail Number	Comments
78-HS-4499	Temporary Inclined Screw Emergency Stop Pull Cord	Vendor	By Vendor	By Vendor	By Vendor	By Vendor	NA	95-IT-102		NA	NA	
78-SSL-4499	Temporary Inclined Screw Low Speed Switch	Vendor	By Vendor	By Vendor	By Vendor	By Vendor	120 VAC	95-IT-102		NA	NA	

SECTION 40 71 00

FLOW MEASUREMENT

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Requirements for instrumentation elements that quantitatively convert the measured variable energy into a form suitable for measurement and process measurement accessories.
   2. Requirements for process flow measurement instruments including meters, transmitters, switches, associated indication devices, and accessories.
   3. Requirements for instrumentation elements which form a part of the process control systems are specified in Section 40 61 13 and Section 40 70 93. Application requirements are specified in the instrument list, Section 40 70 93.

B. Instrument list: Instruments are scheduled in Section 40 70 93.

1.02 RELATED SECTIONS

A. This section contains specific references to related sections listed below. Additional related sections may apply that are not specifically listed below.
   1. Section 40 05 01 Piping Systems
   2. Section 40 61 13 Process Control System General Provisions
   3. Section 40 61 21 Process Control System Testing
   4. Section 40 70 93 Process Control System Instrument List

1.03 REFERENCES

A. This section contains references to documents listed below. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.

Reference	Title
API RP 551	American Petroleum Institute Recommended Practice Process Measurement
NEMA 250	National Electrical Manufacturers Association Enclosures for Electrical Equipment (1000 Volts Maximum)

1.04 SUBMITTALS

A. General:
   1. Procedures: Section 01 33 00
   2. Submittal requirements: Section 40 61 13.

B. Action Submittals:

1. A copy of this specification section, with addendum updates included, and all referenced and applicable sections, with addendum updates included, with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements. Referenced and applicable sections to be marked up and submitted include:
   a. Section 40 70 93 – Process Control System Instrument List
2. A check mark shall denote full compliance with a paragraph as a whole. If deviations from the specifications are indicated, and therefore requested by the Contractor, each deviation shall be underlined and denoted by a number in the margin to the right of the identified paragraph, referenced to a detailed written explanation of the reasons for requesting the deviation. The remaining portions of the paragraph not underlined will signify compliance on the part of the Contractor with the specifications. Failure to include a copy of the marked-up specification sections, along with justification(s) for any requested deviations to the specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration.
3. A copy of the contract document Control Diagrams and Process and Instrumentation Diagrams relating to the submitted equipment, with addendum updates that apply to the equipment in this section, marked to show specific changes necessary for the equipment proposed in the submittal. If no changes are required, the drawing or drawings shall be marked "no changes required". Failure to include copies of the relevant drawings with the submittal shall be cause for rejection of the entire submittal with no further review.
4. Marked Contract Document Mechanical and/or Electrical Plan drawings, sections, and details showing sensor installation locations and details. Failure to include copies of the relevant drawings with the submittal shall be cause for rejection of the entire submittal with no further review.
5. Marked product literature of all equipment and features to be provided.
   a. Installation drawings for only the transmitters, sensors, and mounting accessories to be provided.
   b. Electrical and signal connection drawings for only the transmitters and sensors to be provided.
6. List of miscellaneous items, cables, spare parts, that will be provided in accordance with INSTRUSPEC sheet requirements.
7. Marked product literature for surge protectors if applicable.

C. Closeout Submittals:

1. Procedures: Section 01 78 23.
2. Completed test forms: Section 01 99 90
3. Factory calibration certificates (for Magnetic Flowmeters).
4. Operating and maintenance submittals: Section 01 78 23.
   a. Final reviewed submittals.
   b. Manufacturer’s operation and maintenance instruction, edited for this project.
   c. Record of menu configurations, jumpers, settings (range, set point, deadband) and other configurable parameters for each instrument in electronic form using Microsoft Excel or Word.

d. Hardcopy and electronic copy of final configuration files used for configuration and communication set up of programmable electronic based instruments (or smart instruments. If instrument uses HART programmer, provide the most current HART configuration files.

1.05 QUALITY ASSURANCE

A. Manufacturer: Equipment furnished under this section shall be the products of firms regularly engaged in the design and manufacture of such equipment for a minimum of five years.

B. Installer: Installation, calibration and testing of equipment furnished under this section shall be performed by qualified, skilled, Certified Technicians specified in Section 40 61 13, who are regularly engaged in such activities involving systems of similar complexity.

1.06 ENVIRONMENTAL CONDITIONS

A. Equipment provided under this section shall be suitable for operation under ambient conditions described in Section 40 61 13.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Candidate manufacturers are specified on the INSTRUSPEC sheets in Part 4 of this section. Candidate manufacturers are capable of producing equipment and/or products that will satisfy the requirements of this Section. The manufacturer's standard product may require modification to conform to specified requirements.

2.02 INSTRUMENTATION SPECIFICATION SHEETS (INSTRUSPEC)

A. INSTRUSPEC sheets in Part 4 of this section represent different types of flow measurement instruments. The flow measurement instruments are listed in the instrument schedule, Section 40 70 93 with required INSTRUSPEC symbol specified.

2.03 SYSTEM EQUIPMENT

A. General:
   1. In accordance with Section 01 33 00, the General Conditions of the Contract Documents, drawings, information, and technical data for all equipment as, required in Section 40 61 13 and this section shall be provided. All required product data for this section shall be included in one complete package.

B. Process switches and devices shall comply with the following requirements:
   1. Contact outputs used for alarm actuation shall be normally-opened as required by the process condition to open to initiate the alarm.
   2. Contact outputs used to control equipment shall be normally-opened and shall close to start the equipment.
   3. Contacts monitored by solid state equipment such as programmable controllers or annunciators shall be hermetically sealed and rated for switching currents from 20 to 100 mA at 24 volts DC.

4. Contacts, monitored by electromagnetic devices such as mechanical relays, shall be rated as NEMA ICS 2, designation B300.
5. Double barriers provided between switch elements and process fluids such that failure of one barrier will not permit process fluids into electrical enclosures.
6. Switch electrical enclosures rated as NEMA 250, Type 4 minimum.
7. Switch contacts located in classified areas and monitored by solid-state circuits shall be made safe by intrinsic safety barriers as specified in paragraph 2.05 or an alternative protection method recognized by the NEC.
8. Switch range shall be selected so that the specified set point is at least 30 percent but not more than 70 percent of the span, between the upper range limit and the lower range limit.

C. Measuring elements and transmitters shall comply with the following requirements:
1. Measured parameter output indicators complying with paragraph 2.04 shall be provided with any transmitter that does not include an integral indicator. Indicators, whether integral or separate, shall be calibrated in process units, and engraved on the indicator scale plate.
2. The two-wire type transmitters shall have operating power derived from the signal transmission circuit.
3. Transmitters shall meet specified performance requirements with load variations within the range of 0 to 600 ohms with the power supply at a nominal 24 volts DC with the default range of 0 to 100% linearly corresponding to 4 to 20 mAdc.
4. Transmitter output shall increase with increasing measurement.
5. Transmitter output shall be galvanically isolated via electro-mechanical or optical technology.
6. Transmitter enclosures shall be rated NEMA 250, Type 4, unless otherwise specified.
7. Transmitters located outdoors shall be provided with surge protectors:
   a. Signal: Surgelogic SSP030SSE10HC, or approved equal.
   b. AC Power: UL 1449, LED indicator, screw terminal connections, NEMA 4X. ASCO 252 or approved equal.
8. Two-wire transmitter located in a facility area classified as hazardous per the NFPA and the NEC shall be made safe by means of an intrinsic safety barrier as specified in paragraph 2.05 or an alternative protection method in accordance with the NEC and in coordination with the manufacturer's requirements.
9. Four-wire transmitters shall be isolated from the process and power or provided with a loop-powered signal current isolator as specified in paragraph 2.06 connected in the output signal circuit.

2.04 PROCESS PARAMETER OUTPUT INDICATOR

A. Provide digital LED or LCD indicators integral to the instrument housing where available from the manufacturer. Displays shall be scaled in engineering units, over the calibrated range of the instrument. Calibrate the indicator scale in process units.

B. Analog output indicators shall be 2.5-inch milli-ammeter with 90-degree movement enclosed in an appropriately NEMA rated meter case. Provide indicators with accuracy within two percent of span. Provide a diode to maintain loop continuity for indicator removal.

2.05 INTRINSIC SAFETY BARRIERS

A. Intrinsic safety barriers shall be of the active, isolating, loop powered type. Barrier shall be Eaton Type MTL7787, Stahl Series 9000, or approved equal.

2.06 SIGNAL CURRENT ISOLATOR

A. Application: Four-wire transmitters if required per paragraph 2.03.

B. Isolator shall provide galvanic isolation of milliampere transmission signals from transmitters. Isolator shall be housed in a NEMA 250, Type 4/7 conduit body and derive operating power from the signal input circuit.

C. Input and output signals shall be 4 to 20 milliamperes, and error shall not exceed 0.1 percent of span. Input resistance shall not exceed 550 ohms with an output load of 250 ohms.

D. Isolator shall be Moore Industries SCX 4-20 mAdc to 4-20 mAdc / 5.5VPL / -RF DIN rail mounted with maximum 250 ohm output impedance, or approved equal.

PART 3 EXECUTION

3.01 INSTALLATION

A. General:
   1. General requirements for the installation of primary elements specified in this section are listed on INSTRUSPEC sheets.
   2. Installation requirements are specified in Section 40 61 13.

B. Process Connections:
   1. General: Unless otherwise specified, process taps shall comply with Section 40 05 01. Process connections shall be arranged such that instruments may be readily removed for maintenance without disruption of process units or draining of large tanks or vessels. Unions or flange connections shall be provided as necessary to permit removal without rotating equipment.
      a. Where process taps are not readily accessible from instrument locations, an isolation valve shall be provided at the instrument.
      b. Isolation valves shall be provided for each instrument where multiple instruments are connected to one process tap.
      c. Pipe between the process connection and instruments shall be 1/2-inch stainless steel with treatment material for easy removal, as specified herein.

C. Electrical Connections:
   1. Final connections between rigid raceway systems and instruments shall be made with jacketed flexible conduit with a maximum length of 2 feet.

D. Outdoor Transmitters:
   1. Transmitters mounted outdoors shall be provided with rain/sun hood.
   2. Provide instruments and impulse lines with insulation and heat trace when specified for cold climates reaching temperature below freezing.

3.02 FIELD QUALITY CONTROL

A. Testing requirements are specified in Section 40 61 21.

3.03 PROCESS CONNECTIONS:

A. Process connection piping and tubing shall be tested in accordance with Section 40 05 01.

3.04 TRAINING

A. Training requirements are specified in Section 01 79 00. Provide one training session, with one-half hour for each type of flow measurement instrument.

PART 4 APPENDIX - INSTRUSPECS

4.01 INSTRUSPECS

A. General requirements for instruments specified in this section are listed on INSTRUSPEC sheets herein. Application requirements are specified in the Instrument List, and/or on the drawings.

Table A

INSTRUSPEC Symbol	Instrument description	Instrument function
FPS	Piston Flow Switch	Flow Measurement

4.02 INSTRUMENT IDENTIFICATION: FPS

A. Instrument Function: Flow Measurement

B. Instrument Description: Piston Flow Switch

C. Manufacturer:
   1. Dwyer Series AFS
   2. Approved equal.

D. Features:
   1. Power Supply: N/A
   2. Signal Input: Process
   3. Signal Output: Contact as specified in paragraph 2.03.
   4. Process Connection: 1/2-inch female NPT
   5. Piston flow switch shall consist of a field adjustable line restriction and a spring-loaded piston in a bypass circuit. The piston shall carry a magnet, which shall activate a hermetically sealed reed switch.
   6. The entire unit enclosed in a brass bar stock housing with brass trim. Actuation point for liquid service adjustable from 0.5 to 5.0 GPM and differential fixed at not more than 15 percent. Pressure drop shall not exceed 2 psi at set point flow.

E. Execution:

1. Installation: Install in accordance with manufacturer's instructions and installation details.

END OF SECTION

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SECTION 40 72 00

LEVEL MEASUREMENT

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Requirements for instrumentation elements that quantitatively convert the measured variable energy into a form suitable for measurement and process measurement accessories.
   2. Requirements for process level measurement instruments including meters, transmitters, switches, associated indication devices, and accessories.
   3. Requirements for instrumentation elements which form a part of the process control systems specified in Section 40 61 13 and Section 40 70 93. Application requirements are specified in the instrument schedule, Section 40 70 93.

B. Instrument list: instruments are scheduled in Section 40 70 93.

1.02 RELATED SECTIONS

A. This section contains specific references to related sections listed below. Additional related sections may apply that are not specifically listed below.
   1. Section 40 61 13 Process Control System General Provisions
   2. Section 40 61 21 Process Control System Testing
   3. Section 40 70 93 Process Control System Instrument List

1.03 REFERENCES

A. This section contains references to documents listed below. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.

Reference	Title
API RP 551	American Petroleum Institute Recommended Practice Process Measurement
NEMA 250	National Electrical Manufacturers Association Enclosures for Electrical Equipment (1000 Volts Maximum)

1.04 SUBMITTALS

A. General:
   1. Procedures: Section 01 33 00
   2. Submittal requirements: Section 40 61 13.

B. Action Submittals:
   1. A copy of this specification section, with addendum updates included, and all referenced and applicable sections, with addendum updates included, with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements. Referenced and applicable sections to be marked up and submitted include:
      a. Section 40 70 93 – Process Control System Instrument List
   2. A check mark shall denote full compliance with a paragraph as a whole. If deviations from the specifications are indicated, and therefore requested by the Contractor, each deviation shall be underlined and denoted by a number in the margin to the right of the identified paragraph, referenced to a detailed written explanation of the reasons for requesting the deviation. The remaining portions of the paragraph not underlined will signify compliance on the part of the Contractor with the specifications. Failure to include a copy of the marked-up specification sections, along with justification(s) for any requested deviations to the specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration.
   3. A copy of the contract document Control Diagrams and Process and Instrumentation Diagrams relating to the submitted equipment, with addendum updates that apply to the equipment in this section, marked to show specific changes necessary for the equipment proposed in the submittal. If no changes are required, the drawing or drawings shall be marked "no changes required". Failure to include copies of the relevant drawings with the submittal shall be cause for rejection of the entire submittal with no further review.
   4. Marked Contract Document Mechanical and/or Electrical Plan drawings, sections, and details showing sensor installation locations and details. Failure to include copies of the relevant drawings with the submittal shall be cause for rejection of the entire submittal with no further review.
   5. Marked product literature of all equipment and features to be provided.
      a. Installation drawings for only the transmitters, sensors, and mounting accessories to be provided.
      b. Electrical and signal connection drawings for only the transmitters and sensors to be provided.
   6. List of miscellaneous items, cables, spare parts, that will be provided in accordance with INSTRUSPEC sheet requirements.
   7. Marked product literature for surge protectors if applicable.

C. Closeout Submittals:
   1. Procedures: Section 01 78 23.
   2. Completed test forms: Section 01 99 90
   3. Factory calibration certificates.
   4. Operating and maintenance submittals: Section 01 78 23.
      a. Final reviewed submittals.
      b. Manufacturer’s operation and maintenance instruction, edited for this project.
      c. Record of menu configurations, jumpers, settings (range, set point, deadband) and other configurable parameters for each instrument in electronic form using Microsoft Excel or Word.

d. Hardcopy and electronic copy of final configuration files used for configuration and communication set up of programmable electronic based instruments (or smart instruments. If instrument uses HART programmer, provide the most current HART configuration files.

1.05 QUALITY ASSURANCE

A. Manufacturer: Equipment furnished under this section shall be the products of firms regularly engaged in the design and manufacture of such equipment for a minimum of five years.

B. Installer: Installation, calibration and testing of equipment furnished under this section shall be performed by qualified, skilled, Certified Technicians specified in Section 40 61 13, who are regularly engaged in such activities involving systems of similar complexity.

1.06 ENVIRONMENTAL CONDITIONS

A. Equipment provided under this section shall be suitable for operation under ambient conditions described in Section 40 61 13.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Candidate manufacturers are specified on the INSTRUSPEC sheets in Part 4 of this section. Candidate manufacturers are capable of producing equipment and/or products that will satisfy the requirements of this Section. The manufacturer's standard product may require modification to conform to specified requirements.

2.02 INSTRUMENTATION SPECIFICATION SHEETS (INSTRUSPEC)

A. INSTRUSPEC sheets in Part 4 of this section represent different types of level measurement instruments. The level measurement instruments are listed in the instrument schedule, Section 40 70 93 with required INSTRUSPEC symbol specified.

2.03 SYSTEM EQUIPMENT

A. General:
   1. In accordance with Section 01 33 00, the General Conditions of the Contract Documents, drawings, information, and technical data for all equipment as, required in Section 40 61 13 and this section shall be provided. All required product data for this section shall be included in one complete package.

B. Process switches and devices shall comply with the following requirements:
   1. Contact outputs used for alarm actuation shall be normally- opened as required by the process condition to open to initiate the alarm.
   2. Contact outputs used to control equipment shall be normally-opened and shall close to start the equipment.
   3. Contacts monitored by solid state equipment such as programmable controllers or annunciators shall be hermetically sealed and rated for switching currents from 20 to 100 mA at 24 volts DC.

4. Contacts, monitored by electromagnetic devices such as mechanical relays, shall be rated as NEMA ICS 2, designation B300.
5. Double barriers provided between switch elements and process fluids such that failure of one barrier will not permit process fluids into electrical enclosures.
6. Switch electrical enclosures rated as NEMA 250, Type 4 minimum.
7. Switch contacts located in classified areas and monitored by solid-state circuits shall be made safe by intrinsic safety barriers as specified in paragraph 2.05 or an alternative protection method recognized by the NEC.
8. Switch range shall be selected so that the specified set point is at least 30 percent but not more than 70 percent of the span, between the upper range limit and the lower range limit.

C. Measuring elements and transmitters shall comply with the following requirements:
1. Measured parameter output indicators complying with paragraph 2.04 shall be provided with any transmitter that does not include an integral indicator. Indicators, whether integral or separate, shall be calibrated in process units, and engraved on the indicator scale plate.
2. The two-wire type transmitters shall have operating power derived from the signal transmission circuit.
3. Transmitters shall meet specified performance requirements with load variations within the range of 0 to 600 ohms with the power supply at a nominal 24 volts DC with the default range of 0 to 100% linearly corresponding to 4 to 20 mAdc.
4. Transmitter output shall increase with increasing measurement.
5. Transmitter output shall be galvanically isolated via electro-mechanical or optical technology.
6. Transmitter enclosures shall be rated NEMA 250, Type 4, unless otherwise specified.
7. Transmitters located outdoors shall be provided with surge protectors:
   a. Signal: Surgelogic SSP030SSE10HC or approved equal.
   b. AC Power: UL 1449, LED indicator, screw terminal connections, NEMA 4X. ASCO 252 or accepted equal.
8. Two-wire transmitter located in a facility area classified as hazardous per the NFPA and the NEC shall be made safe by means of an intrinsic safety barrier as specified in paragraph 2.05 or an alternative protection method in accordance with the NEC and in coordination with the manufacturer's requirements.
9. Four-wire transmitters shall be isolated from the process and power or provided with a loop-powered signal current isolator as specified in paragraph 2.06 connected in the output signal circuit.

2.04 PROCESS PARAMETER OUTPUT INDICATOR

A. Provide digital LED or LCD indicators that integral to the instrument housing where available from the manufacturer. Displays shall be scaled in engineering units, over the calibrated range of the instrument. Calibrate the indicator scale in process units.

B. Analog output indicators shall be 2.5-inch milli-ammeter with 90-degree movement enclosed in an appropriately NEMA rated meter case. Provide indicators with accuracy within two percent of span. Provide a diode to maintain loop continuity for indicator removal.

2.05 INTRINSIC SAFETY BARRIERS

A. Intrinsic safety barriers shall be of the active, isolating, loop powered type. Barrier shall be Eaton Type MTL7787, Stahl Series 9000, or approved equal.

2.06 SIGNAL CURRENT ISOLATOR

A. Application: Four-wire transmitters if required per paragraph 2.03.

B. Isolator shall provide galvanic isolation of milliampere transmission signals from transmitters. Isolator shall be housed in a NEMA 250, Type 4/7 conduit body and derive operating power from the signal input circuit.

C. Input and output signals shall be 4 to 20 milliamperes, and error shall not exceed 0.1 percent of span. Input resistance shall not exceed 550 ohms with an output load of 250 ohms.

D. Isolator shall be Moore Industries SCX 4-20 mAdc to 4-20 mAdc / 5.5VPL / -RF DIN rail mounted with maximum 250 ohm output impedance, or approved equal.

PART 3 EXECUTION

3.01 INSTALLATION

A. General:
   1. General requirements for the installation of primary elements specified in this section are listed on INSTRUSPEC sheets.
   2. Installation requirements are specified in Section 40 61 13.

B. Process Connections:
   1. General: Unless otherwise specified, process taps shall comply with Section 40 05 01. Process connections shall be arranged such that instruments may be readily removed for maintenance without disruption of process units or draining of large tanks or vessels. Unions or flange connections shall be provided as necessary to permit removal without rotating equipment.
      a. Where process taps are not readily accessible from instrument locations, an isolation valve shall be provided at the instrument.
      b. Isolation valves shall be provided for each instrument where multiple instruments are connected to one process tap.
      c. Pipe between the process connection and instruments shall be 1/2-inch stainless steel with treatment material for easy removal, as specified herein.

C. Electrical Connections:
   1. Final connections between rigid raceway systems and instruments shall be made with jacketed flexible conduit with a maximum length of 2 feet.

D. Outdoor Transmitters:
   1. Transmitters mounted outdoors shall be provided with rain/sun hood.
   2. Provide instruments and impulse lines with insulation and heat trace when specified for cold climates reaching temperature below freezing.

3.02 FIELD QUALITY CONTROL

A. Testing requirements are specified in Section 40 61 21.

3.03 PROCESS CONNECTIONS:

A. Process connection piping shall be tested in accordance with Section 40 05 01.

3.04 TRAINING

A. Training requirements are specified in Sections 01 79 00. Provide one training session, with one-half hour for each type of level transmitter.

PART 4 APPENDIX - INSTRUSPECS

4.01 INSTRUSPECS

A. General requirements for instruments specified in this section are listed on INSTRUSPEC sheets herein. Application requirements are specified in the Instrument List, and/or on the drawings.

Table A

INSTRUSPEC Symbol	Instrument description	Instrument function
LRNC	Non-Contact Radar Level Transmitter	Level Measurement

4.02 INSTRUMENT IDENTIFICATION: LRNC

A. Instrument Function: Level Measurement

B. Instrument Description: Non-Contact Radar Level Transmitter

C. Manufacturer:
   1. Endress + Hauser FMR6X Series
   2. Approved equal.

D. Features:
   1. Power Supply: Loop Powered (2-wire)
   2. Signal Input: Process
   3. Signal Output: Analog 4-20 mA signal as specified in paragraph 2.03 with HART Protocol
   4. Integral Sensor and Signal Converter/Transmitter.
   5. Sensor:
      a. Process Connection Size: 4 inch
      b. Process Connection Type: flanged
      c. Frequency range: 80 GHz technology.
      d. Maximum Acceptable Beam Angle: 6 Degrees or less
      e. Antenna Wetted Materials: PVDF, PTFE, or approved.
      f. Ambient Temperature Range: -40 to +80°C

g. Process Temperature Range: -40 to +80°C
h. Pressure Range: 0 to 25 psig.

6. Signal Converter/Transmitter:
   a. Enclosure: NEMA 4X, IP66
   b. Measuring range: 0-20 meters or greater.
   c. Accuracy: ±3 mm
   d. Analog Output: One isolated 4-20 mA.
   e. Bluetooth enabled
7. Accessories:
   a. Provide mounting hardware and cable length required to connect the Transmitter and Remote Indicator.

E. Execution:
1. Installation: Install in accordance with manufacturer's instructions and the Engineer's installation detail.
2. Contractor to verify size and type of specified tank connection with approved tank submittals.

END OF SECTION

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SECTION 40 73 00

PRESSURE MEASUREMENT

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Requirements for instrumentation elements that quantitatively convert the measured variable energy into a form suitable for measurement and process measurement accessories.
   2. Requirements for process pressure, strain and force measurement instruments including meters, transmitters, switches, associated indication devices, and accessories.
   3. Requirements for instrumentation elements which form a part of the process control systems specified in Section 40 61 13 and Section 40 70 93. Application requirements are specified in the instrument schedule, Section 40 70 93.

B. Instrument list: Instruments are scheduled in Section 40 70 93.

1.02 RELATED SECTIONS

A. This section contains specific references to related sections listed below. Additional related sections may apply that are not specifically listed below.
   1. Section 40 61 13 Process Control System General Provisions
   2. Section 40 61 21 Process Control System Testing
   3. Section 40 70 93 Schedules for Instrumentation of Process Systems

1.03 REFERENCES

A. This section contains references to documents listed below. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.

Reference	Title
API RP 551	American Petroleum Institute Recommended Practice Process Measurement
NEMA 250	National Electrical Manufacturers Association Enclosures for Electrical Equipment (1000 Volts Maximum)

1.04 SUBMITTALS

A. General:
   1. Procedures: Section 01 33 00
   2. Submittal requirements: Section 40 61 13.

B. Action Submittals:
   1. A copy of this specification section, with addendum updates included, and all referenced and applicable sections, with addendum updates included, with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements. Referenced and applicable sections to be marked up and submitted include:
      a. Section 40 70 93 – Schedules for Instrumentation of Process Systems
   2. A check mark shall denote full compliance with a paragraph as a whole. If deviations from the specifications are indicated, and therefore requested by the Contractor, each deviation shall be underlined and denoted by a number in the margin to the right of the identified paragraph, referenced to a detailed written explanation of the reasons for requesting the deviation. The remaining portions of the paragraph not underlined will signify compliance on the part of the Contractor with the specifications. Failure to include a copy of the marked-up specification sections, along with justification(s) for any requested deviations to the specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration.
   3. A copy of the contract document Control Diagrams and Process and Instrumentation Diagrams relating to the submitted equipment, with addendum updates that apply to the equipment in this section, marked to show specific changes necessary for the equipment proposed in the submittal. If no changes are required, the drawing or drawings shall be marked "no changes required". Failure to include copies of the relevant drawings with the submittal shall be cause for rejection of the entire submittal with no further review.
   4. Marked Contract Document Mechanical and/or Electrical Plan drawings, sections, and details showing sensor installation locations and details. Failure to include copies of the relevant drawings with the submittal shall be cause for rejection of the entire submittal with no further review.
   5. Marked product literature of all equipment and features to be provided.
      a. Installation drawings for only the transmitters, sensors, and mounting accessories to be provided.
      b. Electrical and signal connection drawings for only the transmitters and sensors to be provided.
   6. List of miscellaneous items, cables, spare parts, that will be provided in accordance with INSTRUSPEC sheet requirements.

C. Closeout Submittals:
   1. Procedures: Section 01 78 23.
   2. Completed test forms: Section 01 99 90
   3. Factory calibration certificates.
   4. Operating and maintenance submittals: Section 01 78 23.
      a. Final reviewed submittals.
      b. Manufacturer’s operation and maintenance instruction, edited for this project.
      c. Record of menu configurations, jumpers, settings (range, set point, deadband) and other configurable parameters for each instrument in electronic form using Microsoft Excel or Word.

d. Hardcopy and electronic copy of final configuration files used for configuration and communication set up of programmable electronic based instruments (or smart instruments. If instrument uses HART programmer, provide the most current HART configuration files.

1.05 QUALITY ASSURANCE

A. Manufacturer: Equipment furnished under this section shall be the products of firms regularly engaged in the design and manufacture of such equipment for a minimum of five years.

B. Installer: Installation, calibration and testing of equipment furnished under this section shall be performed by qualified, skilled, Certified Technicians specified in Section 40 61 13, who are regularly engaged in such activities involving systems of similar complexity.

1.06 ENVIRONMENTAL CONDITIONS

A. Equipment provided under this section shall be suitable for operation under ambient conditions described in Section 40 61 13.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Candidate manufacturers are specified on the INSTRUSPEC sheets in Part 4 of this section. Candidate manufacturers are capable of producing equipment and/or products that will satisfy the requirements of this Section. The manufacturer's standard product may require modification to conform to specified requirements.

2.02 INSTRUMENTATION SPECIFICATION SHEETS (INSTRUSPEC)

A. General requirements for instruments specified in this section are specified in Part 4 on the INSTRUSPEC sheets in this section.

B. Application requirements are specified in Section 40 70 93 and/or on the drawings.

2.03 SYSTEM EQUIPMENT

A. General:
   1. In accordance with Section 01 33 00, the General Conditions of the Contract Documents, drawings, information, and technical data for all equipment as, required in Section 40 61 13 and this section shall be provided. All required product data for this section shall be included in one complete package.

B. Process switches and devices shall comply with the following requirements:
   1. Contact outputs used for alarm actuation shall be normally-open as required by the process condition to open to initiate the alarm.
   2. Contact outputs used to control equipment shall be normally-open and shall close to start the equipment.

3. Contacts monitored by solid state equipment such as programmable controllers or annunciators shall be hermetically sealed and rated for switching currents from 20 to 100 mA at 24 volts DC.
4. Contacts, monitored by electromagnetic devices such as mechanical relays, shall be rated as NEMA ICS 2, designation B300.
5. Double barriers provided between switch elements and process fluids such that failure of one barrier will not permit process fluids into electrical enclosures.
6. Switch electrical enclosures rated as NEMA 250, Type 4 minimum.
7. Switch contacts located in classified areas and monitored by solid-state circuits shall be made safe by intrinsic safety barriers as specified in paragraph 2.05 or an alternative protection method recognized by the NEC.
8. Switch range shall be selected so that the specified set point is at least 30 percent but not more than 70 percent of the span, between the upper range limit and the lower range limit.

C. Measuring elements and transmitters shall comply with the following requirements:
1. Measured parameter output indicators complying with paragraph 2.04 shall be provided with any transmitter that does not include an integral indicator. Indicators, whether integral or separate, shall be calibrated in process units, and engraved on the indicator scale plate.
2. The two-wire type transmitters shall have operating power derived from the signal transmission circuit.
3. Transmitters shall meet specified performance requirements with load variations within the range of 0 to 600 ohms with the power supply at a nominal 24 volts DC with the default range of 0 to 100% linearly corresponding to 4 to 20 mAdc.
4. Transmitter output shall increase with increasing measurement.
5. Transmitter output shall be galvanically isolated via electro-mechanical or optical technology.
6. Transmitter enclosures shall be rated NEMA 250, Type 4, unless otherwise specified.
7. Two-wire transmitter located in a facility area classified as hazardous per the NFPA and the NEC shall be made safe by means of an intrinsic safety barrier as specified in paragraph 2.05 or an alternative protection method in accordance with the NEC and in coordination with the manufacturer's requirements.
8. Four-wire transmitters shall be isolated from the process and power or provided with a loop-powered signal current isolator as specified in paragraph 2.06 connected in the output signal circuit.

2.04 PROCESS PARAMETER OUTPUT INDICATOR

A. Provide digital LED or LCD indicators integral to the instrument housing where available from the manufacturer. Displays shall be scaled in engineering units, over the calibrated range of the instrument. Calibrate the indicator scale in process units.

B. Analog output indicators shall be 2.5-inch milli-ammeter with 90-degree movement enclosed in an appropriately NEMA rated meter case. Provide indicators with accuracy within two percent of span. Provide a diode to maintain loop continuity for indicator removal.

2.05 INTRINSIC SAFETY BARRIERS

A. Intrinsic safety barriers shall be of the active, isolating, loop powered type. Barrier shall be Eaton Type MTL7787 or approved equal.

2.06 SIGNAL CURRENT ISOLATOR

A. Isolator shall provide galvanic isolation of milliampere transmission signals from transmitters. Isolator shall be housed in a NEMA 250, Type 4/7 conduit body and derive operating power from the signal input circuit.

B. Input and output signals shall be 4 to 20 milliamperes, and error shall not exceed 0.1 percent of span. Input resistance shall not exceed 550 ohms with an output load of 250 ohms.

C. Isolator shall be Moore Industries SCX 4-20 mAdc to 4-20 mAdc / 5.5VPL / -RF DIN rail mounted] with maximum 250 ohm output impedance, or approved equal.

2.07 ROOT VALVES, GAUGE VALVES, AND VALVE MANIFOLDS

A. Root Valves:
   1. Application: Isolation of instrumentation from a process line
   2. Root valves shall be 316 stainless steel ball valves with 1/2-inch MNPT process connection and one 1/2-inch NPT female instrument connection.
   3. Connect root valves to process tap.

B. Gauge Valves:
   1. Application: Connection for pressure gauges and pressure switches to the root valve or piping from the root valve
   2. Gauge valves shall be machined from Type 316 stainless steel bar stock and shall be provided with 1/2-inch MNPT inlet connection (process side), 1/2-inch FNPT outlet connection (instrument side), and integral bleed plug.
   3. Gauge Valve Manufacturers:
      a. Anderson Greenwood M9 VIS-44
      b. Hoke 6801L8Y
      c. Or approved equal.

C. Valve Manifolds:
   1. Application: Connection for pressure indicating transmitters and differential pressure indicating transmitters to the root valve or piping from the root valve.
   2. Valve manifold body shall be machined from ASTM Type 316 stainless steel bar stock. Valves shall be globe configuration with 316 stainless steel ball seats.
   3. Pressure Instrumentation:
      a. Valve manifolds shall be two-valve bar-stock type for gauge pressure transmitters.
      b. Valve manifolds shall be designed for direct mounting to pressure transmitters

c. Valve manifold manufacturers:
    1) Manufacturer of the manifold shall match the manufacturer of the pressure instrumentation

4. Differential Pressure Instrumentation:
    a. Valve manifolds shall be three-valve bar-stock type for differential pressure transmitters.
    b. Valve manifolds shall be designed for direct mounting to differential pressure transmitters.
    c. Valve manifold manufacturers:
        1) Manufacturer of the manifold shall match the manufacturer of the pressure instrumentation

2.08 DIAPHRAGM AND ANNULAR SEALS

A. Where shown on contract drawings, provide seals assembled to the pressure instrument.

B. Diaphragm Seals:
    1. Provide ¾" process connections and ½" instrument connections.
    2. Provide seal flushing connection Type 316 stainless steel interconnecting fitting, and plug for the flushing connection.
    3. All-welded construction.
    4. Manufacturer shall match instrument supplier.

C. Annular Seals:
    1. Seal shall be the in-line full stream captive sensing liquid type. Metallic wetted parts shall be Type 316 stainless steel. Flexible cylinder shall be Buna-N unless otherwise specified. Seals shall be rated 200 psig with not more than 5-inch water column (WC) hysteresis.
    2. Provide seal flushing connection Type 316 stainless steel interconnecting fitting, and plug for the flushing connection.
    3. Manufacturer shall match instrument supplier.

D. Fill Fluid:
    1. Chemical seals and associated instruments shall be factory filled as follows:
        a. Instrument side of seal, capillary tubing, and instrument shall be evacuated to an absolute pressure of 1.0 Torr or less; filled; and sealed. Provide silicone oil fill fluid, halocarbon fill fluid for chlorine applications, unless otherwise recommended by the seal manufacturer.
        b. Chemical seal manufacture: Dow Corning DC200, Syltherm 800, or equal.

2.09 PRODUCT DATA

A. Additional Information: The following product data shall be provided:
    1. Record documentation shall include the data sheets specified in this section.

B. The following data provided in accordance with Section 01 33 00:
   1. Operating and maintenance information as specified in Section 40 61 13. Include final reviewed submittal and separate record of all final configuration, jumper, and switch settings for each instrument.
   2. Test results as specified in Section 40 61 21.

PART 3 EXECUTION

3.01 INSTALLATION

A. General:
   1. General requirements for the installation of primary elements specified in this section are listed on INSTRUSPEC sheets.
   2. Installation requirements are specified in Section 40 61 13.

B. Process Connections:
   1. General: Unless otherwise specified, process taps shall comply with Section 40 05 01. Process connections shall be arranged such that instruments may be readily removed for maintenance without disruption of process units or draining of large tanks or vessels. Unions or flange connections shall be provided as necessary to permit removal without rotating equipment.
      a. Where process taps are not readily accessible from instrument locations, a root valve shall be provided at the process tap.
      b. Gauge valves shall be provided for each instrument where multiple instruments are connected to one process tap.
      c. Pipe between the process connection and instruments shall be 1/2-inch stainless steel with treatment material for easy removal, as specified herein.
   2. Root valves shall be provided at all process taps, except as follows:
      a. Process taps for safety instruments.
      b. Where chemical seals are used.
   3. Gauge Valves or Valve Manifolds shall be provided for each pressure instrument.

C. Tubing:
   1. Tubing shall be installed on supports spaced not more than 3 feet apart and shall run parallel of perpendicular to walls structural members, or intersections of vertical planes and the ceiling. Unless otherwise shown, tubing shall follow building surfaces closely or shall be carried in trays or conduit.
   2. Tubing shall not be supported from piping or equipment except at process taps or connections to the device served. Tubes supported directly on concrete surfaces shall be spaced at least 1/8 inch from the concrete. Tubing support shall be one-hole malleable iron clamps with clamp backs as required. Bends shall be formed to uniform radii without flattening.
   3. Ends of tubing shall be square-cut and de-burred before installation in fittings. Fittings shall be used for splices, connections, and turns near final connections. Bulkhead fittings shall be used when tubing enters a panel.

D. Electrical Connections:
   1. Final connections between rigid raceway systems and instruments shall be made with jacketed flexible conduit with a maximum length of 2 feet.

3.02 FIELD QUALITY CONTROL

A. Testing requirements are specified in Section 40 61 21.

3.03 PROCESS CONNECTIONS:

A. Process connection piping and tubing shall be tested in accordance with Section 40 05 01.

3.04 TRAINING

A. Training requirements are specified in Sections 01 79 00. Provide two training sessions, each with one-half hour for each type of level transmitter.

PART 4 APPENDIX - INSTRUSPECS

4.01 INSTRUSPECS

A. General requirements for instruments specified in this section are listed on INSTRUSPEC sheets herein. Application requirements are specified in the Instrument Index, and/or on the drawings.

TABLE A

INSTRUSPEC Symbol	Instrument description	Instrument function
PG	Pressure Gauge	Pressure measurement
PS	Pressure Switch	Pressure Measurement

4.02 INSTRUMENT IDENTIFICATION: PG

A. Instrument Function: Pressure measurement

B. Instrument Description: Pressure Gauge

C. Features:
   1. Signal Input: Process pressure
   2. Process Connection: 1/2-inch male NPT
   3. Product Requirements: Pressure gauges shall be 4-1/2-inch premium grade, glycerin filled units with bourdon tube element, 270-degree milled stainless steel movement, phenolic case, and shatterproof glass window. Accuracy shall be 1 percent of span or better. All exposed metal parts shall be stainless steel.

D. Manufacturer:
   1. Ashcroft Duragauge Figure 1279
   2. Approved equal.

E. Execution:
   1. Installation: Install in accordance with manufacturer's instructions and installation details.
   2. Root valves shall be provided at all process pressure taps.
   3. Gauge valves shall be provided at the instrument and connected directly to the instrument. Include for each instrument where two or more instruments are connected to a single tap.
   4. Pressure instruments shall be located as close as practical to the process tap and be positioned to permit observation and maintenance.
   5. Where shown on contract drawings, provide diaphragm seals and annular seals.
   6. Pressure instruments for use with integral seals, or remote seals and capillary tubing provided by a single manufacturer, and all components factory-assembled prior to shipping.
   7. Application/Calibration: Application and instrument range shall be as specified in Section 40 70 93.

4.03 INSTRUMENT IDENTIFICATION: PS

A. Instrument Function: Pressure Measurement

B. Instrument Description: Pressure Switch

C. Features:
   1. Signal Input: Process
   2. Signal Output: As specified in paragraph 2.03
   3. Process Connection: 1/2-inch NPT
   4. Product Data:
      a. Pressure switch shall consist of a pressure transducer and a precision switch. Pressure transducer shall be the diaphragm piston type with wetted materials as recommended by the switch manufacturer. Piston backed by a cylinder disc to permit 10 times over-range pressure without affecting calibration.
      b. Range spring and piston shall be isolated from process fluids by the diaphragm. Switch provided with two 3/4-inch conduit connections. Switch assembly housing shall be cast aluminum rated types 3, 4, and 7D per NEMA ICS6. Contractor shall select pressure transducer so that set point falls between 30 and 70 percent of maximum range.
      c. Approximate set point and, if applicable, reset point indicated on calibrated scales. Repeatability and sensitivity shall be 1.0 percent of operating range. Unless otherwise specified, switches nonadjustable deadband type.

D. Manufacturer:
   1. Ashcroft B Series
   2. Approved equal.

E. Execution:

1. Installation: Install in accordance with manufacturer's instructions and installation details.
2. Root valves shall be provided at all process pressure taps.
3. Gauge valves shall be provided at the instrument and connected directly to the instrument. Include for each instrument where two or more instruments are connected to a single tap.
4. Pressure instruments shall be located as close as practical to the process tap and be positioned to permit observation and maintenance.
5. Where shown on contract drawings, provide diaphragm seals and annular seals.
6. Pressure instruments for use with integral seals, or remote seals and capillary tubing provided by a single manufacturer, and all components factory-assembled prior to shipping.
7. Application/Calibration: Application and instrument range shall be as specified in Section 40 70 93.

END OF SECTION

SECTION 40 75 00

PROCESS LIQUID ANALYTICAL MEASUREMENT

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:
   1. Requirements for instrumentation elements that quantitatively convert the measured variable energy into a form suitable for measurement and process measurement accessories.
   2. Requirements for process liquid analytical measurement instruments including meters, transmitters, switches, associated indication devices, and accessories.
   3. Requirements for instrumentation elements which form a part of the process control systems specified in Section 40 61 13 and Section 40 70 93. Application requirements are specified in the instrument schedule, Section 40 70 93.

B. Instrument list: instruments are scheduled in Section 40 70 93.

1.02 RELATED SECTIONS

A. This section contains specific references to related sections listed below. Additional related sections may apply that are not specifically listed below.
   1. Section 40 61 13 Process Control System General Provisions
   2. Section 40 61 21 Process Control System Testing
   3. Section 40 70 93 Schedules for Instrumentation of Process Systems

1.03 REFERENCES

A. This section contains references to documents listed below. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.

Reference	Title
API RP 551	American Petroleum Institute Recommended Practice Process Measurement
NEMA 250	National Electrical Manufacturers Association Enclosures for Electrical Equipment (1000 Volts Maximum)

1.04 SUBMITTALS

A. General:
   1. Procedures: Section 01 33 00
   2. Submittal requirements: Section 40 61 13.

B. Action Submittals:

1. A copy of this specification section, with addendum updates included, and all referenced and applicable sections, with addendum updates included, with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements. Referenced and applicable sections to be marked up and submitted include:
   a. Section 40 70 93 – Schedules for Instrumentation of Process Systems
2. A check mark shall denote full compliance with a paragraph as a whole. If deviations from the specifications are indicated, and therefore requested by the Contractor, each deviation shall be underlined and denoted by a number in the margin to the right of the identified paragraph, referenced to a detailed written explanation of the reasons for requesting the deviation. The remaining portions of the paragraph not underlined will signify compliance on the part of the Contractor with the specifications. Failure to include a copy of the marked-up specification sections, along with justification(s) for any requested deviations to the specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration.
3. A copy of the contract document Control Diagrams and Process and Instrumentation Diagrams relating to the submitted equipment, with addendum updates that apply to the equipment in this section, marked to show specific changes necessary for the equipment proposed in the submittal. If no changes are required, the drawing or drawings shall be marked "no changes required". Failure to include copies of the relevant drawings with the submittal shall be cause for rejection of the entire submittal with no further review.
4. Marked Contract Document Mechanical and/or Electrical Plan drawings, sections, and details showing sensor installation locations and details. Failure to include copies of the relevant drawings with the submittal shall be cause for rejection of the entire submittal with no further review.
5. Marked product literature of all equipment and features to be provided.
   a. Installation drawings for only the transmitters, sensors, and mounting accessories to be provided.
   b. Electrical and signal connection drawings for only the transmitters and sensors to be provided.
6. List of miscellaneous items, cables, spare parts, that will be provided in accordance with INSTRUSPEC sheet requirements.

C. Closeout Submittals:

1. Procedures: Section 01 78 23
2. Completed test forms: Section 01 99 90
3. Factory calibration certificates.
4. Operating and maintenance submittals: Section 01 78 23.
   a. Final reviewed submittals.
   b. Manufacturer’s operation and maintenance instruction, edited for this project.
   c. Record of menu configurations, jumpers, settings (range, set point, deadband) and other configurable parameters for each instrument in electronic form using Microsoft Excel or Word.

d. Hardcopy and electronic copy of final configuration files used for configuration and communication set up of programmable electronic based instruments (or smart instruments. If instrument uses HART programmer, provide the most current HART configuration files.

1.05 QUALITY ASSURANCE

A. Manufacturer: Equipment furnished under this section shall be the products of firms regularly engaged in the design and manufacture of such equipment for a minimum of five years.

B. Installer: Installation, calibration and testing of equipment furnished under this section shall be performed by qualified, skilled, Certified Technicians specified in Section 40 61 13, who are regularly engaged in such activities involving systems of similar complexity.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Candidate manufacturers are specified on the INSTRUSPEC sheets in Part 4 of this section. Candidate manufacturers are capable of producing equipment and/or products that will satisfy the requirements of this Section. The manufacturer's standard product may require modification to conform to specified requirements.

2.02 INSTRUMENTATION SPECIFICATION SHEETS (INSTRUSPEC)

A. INSTRUSPEC sheets in Part 4 of this section represent different types of analytical measurement instruments. The analytical measurement instruments are listed in the instrument schedule, Section 40 70 93 with required INSTRUSPEC symbol specified.

2.03 SYSTEM EQUIPMENT

A. General:
   1. In accordance with Section 01 33 00, the General Conditions of the Contract Documents, drawings, information, and technical data for all equipment as, required in Section 40 61 13 and this section shall be provided. All required product data for this section shall be included in one complete package.

B. Process switches and devices shall comply with the following requirements:
   1. Contact outputs used for alarm actuation shall be normally-closed or normally-opened as required by the process condition to open to initiate the alarm.
   2. Contact outputs used to control equipment shall be normally-opened and shall close to start the equipment.
   3. Contacts monitored by solid state equipment such as programmable controllers or annunciators shall be hermetically sealed and rated for switching currents from 20 to 100 mA at 24 volts DC.
   4. Contacts, monitored by electromagnetic devices such as mechanical relays, shall be rated as NEMA ICS 2, designation B300.
   5. Double barriers provided between switch elements and process fluids such that failure of one barrier will not permit process fluids into electrical enclosures.

6. Switch electrical enclosures rated as NEMA 250, Type 4 minimum.
7. Switch contacts located in classified areas and monitored by solid-state circuits shall be made safe by intrinsic safety barriers as specified in paragraph 2.05 or an alternative protection method recognized by the NEC.
8. Switch range shall be selected so that the specified set point is at least 30 percent but not more than 70 percent of the span, between the upper range limit and the lower range limit.

C. Measuring elements and transmitters shall comply with the following requirements:
1. Measured parameter output indicators complying with paragraph 2.04 shall be provided with any transmitter that does not include an integral indicator. Indicators, whether integral or separate, shall be calibrated in process units, and engraved on the indicator scale plate.
2. The two-wire type transmitters shall have operating power derived from the signal transmission circuit.
3. Transmitters shall meet specified performance requirements with load variations within the range of 0 to 600 ohms with the power supply at a nominal 24 volts DC with the default range of 0 to 100% linearly corresponding to 4 to 20 mAdc.
4. Transmitter output shall increase with increasing measurement.
5. Transmitter output shall be galvanically isolated via electro-mechanical or optical technology.
6. Transmitter enclosures shall be rated NEMA 250, Type 4, unless otherwise specified.
7. Two-wire transmitter located in a facility area classified as hazardous per the NFPA and the NEC shall be made safe by means of an intrinsic safety barrier as specified in paragraph 2.05 or an alternative protection method in accordance with the NEC and in coordination with the manufacturer's requirements.
8. Four-wire transmitters shall be isolated from the process and power or provided with a loop-powered signal current isolator as specified in paragraph 2.06 connected in the output signal circuit.

2.04 PROCESS PARAMETER OUTPUT INDICATOR

A. Provide digital LED or LCD indicators that integral to the instrument housing where available from the manufacturer. Displays shall be scaled in engineering units, over the calibrated range of the instrument. Calibrate the indicator scale in process units.

B. Analog output indicators shall be 2.5-inch milli-ammeter with 90-degree movement enclosed in an appropriately NEMA rated meter case. Provide indicators with accuracy within two percent of span. Provide a diode to maintain loop continuity for indicator removal.

2.05 INTRINSIC SAFETY BARRIERS

A. Intrinsic safety barriers shall be of the active, isolating, loop powered type. Barrier shall be Eaton Type MTL7787 or approved equal.

2.06 SIGNAL CURRENT ISOLATOR

A. Isolator shall provide galvanic isolation of milliampere transmission signals from transmitters. Isolator shall be housed in a NEMA 250, Type 4/7 conduit body and derive operating power from the signal input circuit.

B. Input and output signals shall be 4 to 20 milliamperes, and error shall not exceed 0.1 percent of span. Input resistance shall not exceed 550 ohms with an output load of 250 ohms.

C. Isolator shall be Moore Industries SCX 4-20 mAdc to 4-20 mAdc / 5.5VPL / -RF DIN rail mounted] with maximum 250 ohm output impedance, or approved equal.

PART 3 EXECUTION

3.01 INSTALLATION

A. General:
   1. General requirements for the installation of primary elements specified in this section are listed on INSTRUSPEC sheets
   2. Installation requirements are specified in Section 40 61 13.

B. Process Connections:
   1. General: Unless otherwise specified, process taps shall comply with Section 40 05 01. Process connections shall be arranged such that instruments may be readily removed for maintenance without disruption of process units or draining of large tanks or vessels. Unions or flange connections shall be provided as necessary to permit removal without rotating equipment.
      a. Where process taps are not readily accessible from instrument locations, an isolation valve shall be provided at the instrument.
      b. Isolation valves shall be provided for each instrument where multiple instruments are connected to one process tap.
      c. Pipe between the process connection and instruments shall be 1/2-inch stainless steel with treatment material for easy removal, as specified herein.
   2. Root Valves: Root valves shall be provided at all process taps, except as follows:
      a. Temperature taps, where valves are unnecessary.
      b. Pump discharge pressure taps where no instrument is permanently installed. Isolation valves shall be provided.
      c. Process taps for safety instruments.
      d. Where gauge valves are provided.
      e. Where chemical seals are used.
   3. Gauge Valves: Gauge valves shall be provided for each pressure gauge tap except where chemical seals are used.
   4. Flushing/Calibration Connection: Provide a tee and isolation valve between the root or gauge valve and the instrument or diaphragm seal.

C. Tubing:

1. Tubing shall be installed on supports spaced not more than 3 feet apart and shall run parallel of perpendicular to walls structural members, or intersections of vertical planes and the ceiling. Unless otherwise shown, tubing shall follow building surfaces closely or shall be carried in trays or conduit.
2. Tubing shall not be supported from piping or equipment except at process taps or connections to the device served. Tubes supported directly on concrete surfaces shall be spaced at least 1/8 inch from the concrete. Tubing support shall be one-hole malleable iron clamps with clamp backs as required. Bends shall be formed to uniform radii without flattening.
3. Ends of tubing shall be square-cut and de-burred before installation in fittings. Fittings shall be used for splices, connections, and turns near final connections. Bulkhead fittings shall be used when tubing enters a panel.

D. Electrical Connections:

1. Final connections between rigid raceway systems and instruments shall be made with jacketed flexible conduit with a maximum length of 2 feet.

3.02 FIELD QUALITY CONTROL

A. Testing requirements are specified in Section 40 61 21.

3.03 PROCESS CONNECTIONS:

A. Process connection piping and tubing shall be tested in accordance with Section 40 05 01.

3.04 TRAINING

A. Training requirements are specified in Sections 01 79 00. Provide two training sessions, each with one-half hour for each type of analytical measurement instrument.

PART 4 APPENDIX – INSTRUSPECS

4.01 INSTRUSPECS

A. General requirements for instruments specified in this section are listed on INSTRUSPEC sheets herein. Application requirements are specified in the Instrument Index, and/or on the drawings.

Table A

INSTRUSPEC Symbol	Instrument Description	Instrument Function
SM	Microwave Type Suspended Solids Analyzer	Suspended Solids Measurement
SO	Optical Type Suspended Solids Analyzer	Suspended Solids Measurement

4.02 INSTRUMENT IDENTIFICATION: SM

A. Instrument Function: Liquid Analytical Measurement

B. Instrument Description: Suspended Solids - Microwave Measurement

C. Manufacturer:
   1. Valmet TS or approved equal.

D. Features:
   1. Power Supply: 120 volts AC
   2. Signal Output: 4 to 20 mA, isolated
   3. Process Connection: ANSI Class 150 Flanged, flow through sensor, insertion type is not acceptable.
   4. Process temperature range: 32° – 212° F.
   5. Pipeline Sensor Ambient temperature range: 14° – 158° F.
   6. Transmitter:
      a. Analyzer transmitter shall be surface mount, IP66 with integral keypad/display and self-diagnostics.
      b. The analyzer shall use microwave “time of flight” measurement, utilizing microwave propagation time to calculate the concentration of the solids flowing in the pipeline independent of flow velocity.
   7. Sensor:
      a. The measuring spool shall be 316 stainless steel, rated to 200 PSIG or greater. The sensor shall have no moving parts.
      b. Measurement Range: 0-25% total solids or greater.
      c. The in-line transmitter shall have a repeatability of +/- 0.01% TS over the entire range.
      d. Sensor housing: IP66, NEMA 4X.
      e. Pipeline Sensor internals to be epoxy lined.
   8. Interconnecting Sensor Cable: Provided by Manufacturer.
   9. Provide flushing flange for the instrument:
      a. Size: match size of the instrument specified in Section 40 70 93.

E. Execution:
   1. Installation:
      a. Install in the vertical orientation.
      b. Installation shall be in accordance with the manufacturer's recommendations.
   2. Provide and install flushing connection for the instrument in accordance with manufacturer's recommendations.
   3. Application/Calibration: In accordance with Section 40 70 93.
   4. Calibration: Calibrate with the Owner. Schedule Owner’s Lab and maintenance personnel in advance with the Construction Manager.
   5. Manufacturer Services:One day per analyzer on-site.

4.03 INSTRUMENT IDENTIFICATION: SO

A. Instrument Function: Liquid Analytical Measurement

B. Instrument Function: Suspended Solids - Optical Measurement

C. Manufacturer:
   1. Valmet LS or approved equal.

D. Features:
   1. Power Supply: 240 volts AC
   2. Signal Output: 4 to 20 mA HART, isolated
   3. Process Connection: Insertion Type Sample Valve
   4. Transmitter:
      a. Analyzer transmitter shall be surface mount, IP 65 with integral keypad/display and self-diagnostics.
      b. Manufacturer: Valmet TCU or approved equal.
   5. Sensor:
      a. Measurement shall be made with stainless steel sensor with dual infrared light beam technique using LED light source.
      b. Measurement Range: 0-0.5% total solids.
      c. Accuracy of less than 7% of reading.
      d. Manufacturer: Valmet LS or approved Equal
   6. Interconnecting Sensor Cable: 10 meters; provided by manufacturer.
   7. Pump: Powered from inverter integrated in the TCU.
   8. Calibration: Provide a Calibration Kit.
   9. Provide all additional mounting accessories and appurtenances required for the application.

E. Execution:
   1. Installation:
      a. Installation shall be in accordance with the manufacturer's recommendations.
      b. Locate the sample point to provide 3xPipe diameters upstream and downstream of pipe straight run.
   2. Application/Calibration: In accordance with Section 40 70 93.
   3. Calibration: Calibrate with the Owner. Schedule Owner’s Lab and maintenance personnel in advance with the Construction Manager.
   4. Manufacturer Services: One day per analyzer on-site.

END OF SECTION

SECTION 41 12 13.16

SHAFTED SCREW CONVEYOR

PART 1 GENERAL

1.01 SUMMARY

A. This Section specifies the screw conveyor system for the conveyance of dewatered biosolids generated from municipal wastewater treatment processes. This Section specifies the conveyor system installed in Building 72, Solids Processing Center. Equipment provided for the temporary dewatering system including temporary conveyors are specified in Section 46 71 01 Temporary Sludge Dewatering Facilities. The screw conveyance system shall be integrated into the existing screw conveyance system, which requires modifying the existing conveyors to accept new components and integrating controls into the Owner's existing control system.

B. The manufacturer providing equipment for this Section is responsible for furnishing the screw conveyor, the motor and drive assembly, the transfer slide gates and electric gate actuators, the discharge chutes, conveyor supports, ancillary items, and for modifications to the existing screw conveyors that are needed for installation of the transfer conveyor. The manufacturer's responsibility extends to field verification of dimensions of existing equipment and structures prior to fabrication of new equipment, testing, and commissioning the system.

C. Equipment numbers associated with items specified in this section are listed in the table below.

1. FKC Screw Presses

Item	Equipment No.
Cake Collection Screw 1	72CON4201

1.02 QUALITY ASSURANCE

A. This Section incorporates by reference the latest revisions of the following documents. They are part of this Section insofar as specified and modified herein. In the event of conflict between the requirements of this Section and those of the listed documents, the requirements of this Section shall prevail. Unless otherwise specified, references to documents shall mean the documents in effect on the effective date of the Agreement. If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued.

Reference	Title
ASTM A480	General Requirements for Flat-Rolled Stainless and Heat-Resisting Steel Plate, Sheet, and Strip
ASTM A 240	Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications
ASTM A 276	Standard Specification for Stainless Steel Bars and Shapes
ASTM A 479	Standard Specification for Stainless Steel Bars and Shapes for Use in Boilers and Other

Reference	Title
	Pressure Vessels
ASTM A 312	Standard Specification for Seamless, Welded, and Heavily Cold Worked Austenitic Stainless Steel Pipes
ASTM A380	Standard Practice for Cleaning, Descaling, and Passivation of Stainless Steel Parts, Equipment, and Systems

B. Unit Responsibility:
   1. General: The Contractor shall assign unit responsibility, as specified in Section 43 05 11, to the screw conveyor system manufacturer for the conveyor system specified in this Section. Complete and sign the certificate of unit responsibility provided at the end of this Section.
   2. Responsibilities: The unit responsibility supplier shall select and furnish all of the components specified in this section and certain components specifically detailed in related sections where included by specific reference. In addition, the unit responsibility supplier shall be responsible for the following:
      a. Confirming existing conditions within the conveyor room including horizontal dimensions, vertical distances, and clearances around existing equipment and features.
      b. Preparation of conveyor and slide gate fabrication and installation drawings. Installation drawings shall clearly identify existing conditions and physical constraints. The layout of the new equipment shall accommodate the existing conditions and constraints.
      c. Design and installation of transition pieces that are necessary to connect new equipment to existing equipment.
      d. Coordination of production, factory testing, and delivery of all components furnished under the provisions of this Section.
      e. Coordination between operation and control of the existing conveyance system components and new components furnished and installed under this Contract.
      f. Integration of control and electrical systems associated with the equipment furnished and for insuring compatibility with external systems where interconnections are required.
      g. Final alignment, testing, initial start-up and commissioning of the equipment in accordance with the provisions of Section 01 91 00 and requirements specified in this Section.
      h. Training, as specified in this Section and related sections.
      i. Production and delivery of operation and maintenance information as specified in this Section.
      j. Production of required documentation.

C. Factory Testing: The components of the conveyance system shall be factory assembled, inspected, and tested before being packed for shipping.
   1. The inspection and testing shall include the following minimum requirements:
      a. Verification of all materials used for construction.
      b. Dimensional check of all fabricated components.
      c. Quality assurance of all welds.

d. Testing of all motors, gearboxes, controls, safety equipment (including emergency stops), and electrically actuated gates.
e. Certificate that an inspection was conducted and that all materials and workmanship meet specification.

D. Manufacturer's Experience:
1. Qualified manufacturers shall have minimum 5 years' experience manufacturing screw conveyors similar to the type described in this Section. The manufacturer shall have at least 15 screw conveyor installations in the United States at separate locations. At least 7 of the installations must have been in continuous service for at least four years.
2. To verify experience, the manufacturer shall submit a comprehensive installation list including the location of the installation, date of installation, capacity, service requirements, and performance criteria. Contact information for someone currently associated with the operation and maintenance of the equipment shall be provided for at least 7 installations that have been in continuous service for at least 4 years.

1.03 SUBMITTALS

A. Procedures: In compliance with Section 01 33 00.

B. Submittal Items:
1. Certificate of Unit Responsibility. No other submittal material will be reviewed until the certificate has been received and found to be in conformance with these requirements.
2. A copy of this specification section, with addendum updates included, and all referenced and applicable sections, with addendum updates included, with each paragraph check-marked (✓) to indicate specification compliance or marked to indicate requested deviations from specification requirements. Check marks shall denote full compliance with a paragraph as a whole. If deviations from the specifications are indicated and, therefore requested by the Vendor, each deviation shall be underlined and denoted by a number in the margin to the right of the identified paragraph. The remaining portions of the paragraph not underlined will signify compliance on the part of the Vendor with the specifications. 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(s) for any requested deviations to the specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration.
3. Manufacturer's experience statement with a list of installations and contact information.
4. Manufacturer's data confirming rated capacity, safety provisions, equipment weight, and electrical requirements.
5. Shop drawings showing the layout of the new transfer screw conveyor, equipment dimensions, drain connections, electrical connections, instrumentation, and structural connections.
6. Conveyor and slide gate fabrication drawings showing materials of construction, structural member sizes and locations of appurtenances.

7. Shop drawings showing the modifications to the existing screw conveyors that are needed to integrate the new transfer conveyor into the existing conveyance system. Provide a list of components and materials of construction.
8. Certification attesting that all stainless steel components have been cleaned, passivated and tested in accordance with the procedures described in this section.
9. List of spare parts or special equipment.
10. Product data for all auxiliary components.
11. Motor sizing calculation based on the design requirements specified in this Section.
12. Sizing calculations for slide gate actuators based on force requirements.
13. Stamped and signed anchorage system calculations as specified in Section 01 73 24.
14. Electrical internal connection diagrams, and external interconnection diagrams, drawn in accordance with JIC and/or ICS standards. Connection diagrams shall be the conventional type with lines showing point-to-point wiring, terminals, and devices as viewed by the electrician; wireless or wire schedule types are not acceptable.
15. Range and settings for indicators, instruments, timers, and other related devices.
16. Operating and Maintenance information as specified in Section 01 78 23.
17. Equipment Warranty.
18. Factory test and inspection results as required in this Section.
19. Installation Manual containing instructions to be followed in the installation of the equipment. The manual, as a minimum, shall contain the following information:
    a. Major parts list including weights of component parts.
    b. Procedures to be followed in unpacking and unloading, including directions indicating proper methods for moving the equipment.
    c. Instructions for field assembling of match/marked components as they will be shipped.
    d. Instructions for alignment, leveling, and all pertinent information for the proper installation of the equipment.
    e. Instructions for anchoring the equipment.
    f. Wiring instructions for electrical components.
20. Site storage and protection requirements for the equipment prior to installation.

1.04 SEISMIC ANCHORAGE AND STRUCTURAL DATA

A. Mechanical, instrumentation and control, electrical, nonstructural systems, components, and elements permanently attached to the structure shall be anchored and braced to resist seismic forces. Manufacturer shall design the structural components, seismic attachment, braces, and anchors to existing structures for all parts or elements of the mechanical and electrical systems in accordance with Section 01 73 24. Calculations shall be stamped by a professional engineer registered in the State of Washington.

1.05 PERFORMANCE REQUIREMENTS

A. Service Conditions: Equipment shall be suitable for installation and service at a wastewater treatment plant for conveyance of dewatered sludge.

Service Conditions	
Area Exposure	indoor wet
Material Being Conveyed	Anaerobically digested sludge from municipal wastewater, dewatered using screw press, with total solids concentration between a minimum of 15 percent by weight and a maximum of 20 percent by weight.

B. Design Requirements: The transfer screw conveyance system shall be designed for the conditions listed in the table below.

Criteria	Value
Material conveyed	Dewatered digested municipal sludge
Avg. material density	65 - 75 lbs/cf
Capacity	4.5 wet tons per hour
Number conveyors	1
Nominal conveyor length	See Drawings, field confirmation required. Final discharge location is the biosolids storage bay.
Basis of Design – Fill Volume	30% full
Conveyor incline	Zero
Minimum shaft diameter and wall thickness	as determined by manufacturer to meet shaft deflection requirements
Spiral diameter	as determined by manufacturer to meet specified capacity
Spiral pitch	as determined by manufacturer to meet specified capacity
Spiral speed	20 rpm max
Trough diameter	Minimum 12 inches
Trough thickness	3/16 inch
Cover thickness	3/32 inch
Cover panel length, max.	48 inches
Chute thickness	10 ga
Motors	as determined by manufacturer based on design requirements, 5 HP minimum
Discharge locations	Cake transfer screw (with slide gate) Biosolids storage bay (open discharge)
Total number slide gates	1
Discharge gate actuators	Electric
Drain Connections	1 4” drain per conveyor

PART 2 PRODUCTS

2.01 GENERAL

A. This section describes the general requirements, design features and functionality of the screw conveyor system. Screw conveyor systems without these design features and functionality will not be acceptable.

B. The Scope of supply shall include but not be limited to the troughs, trough covers, rotor with spiral flights, chutes, end shafts, electric motors and gear reducers, floor supports, fabricated connection pieces to connect the existing conveyor to the new equipment, seismic restraints, slide gates with electric actuators, safety accessories, spare parts, and all other incidentals for a fully functioning spiral screw conveyor system.

C. Stainless steel fabrications shall be cleaned to remove all scale and welding carbon by pickling and passivating, then rinsed.

D. All welds shall be continuous unless otherwise specified. Facing surfaces of field-welded components shall be beveled and match marked. Sharp corners of all cut and sheared edges shall be made smooth.

2.02 CANDIDATE MANUFACTURERS/PRODUCTS

A. Candidate manufactures are listed below. To conform to specified requirements, the manufacturer's standard product may require modification.
   1. Fukoku Kogyo Company (FKC)Approved equal

2.03 MATERIALS

A. The materials of construction shall meet or exceed the following:

Component	Material
All fabricated components not listed below	ASTM A240 Type 304L stainless steel
Gaskets	Neoprene
Fasteners and misc. hardware	ASTM A240 Type 316 stainless steel

2.04 PASSIVATION OF STAINLESS STEEL

A. General:
   1. Equipment specified under this section shall be cleaned and passivated in accordance with methods defined in ASTM A380 – Standard Practice for Cleaning, Descaling, and Passivation of Stainless Steel Parts, and the specific requirements of this section.
   2. For purposes of this section, cleaning and passivation is defined as the removal of surface contaminants including exogenous iron or iron compounds and the removal of oxide films from the surface of stainless steel by means of mechanical cleaning and mechanical descaling.
   3. The processes specified in this section shall be performed in the manufacturer's facility or in a shop specializing in post fabrication treatment of stainless steel.

4. Equipment components that bolt together shall be disassembled prior to passivation to provide access to all surfaces of the equipment.
5. All fasteners and anchor bolts required for assembly and mounting of equipment shall conform to the requirements of Section 43 05 11.
6. The use of "fabricator's crayons" shall be prohibited during fabrication of equipment as these marks may prevent proper passivation.

B. Passivation Process Requirements:
1. The processes required for proper passivation shall include precleaning, mechanical descaling, post-treatment inspection, testing, certification, and protection as defined below.
   a. Precleaning – Precleaning required for the removal of all grease, oil, paint, soil, grit and other gross contaminants preparatory to the fabrication process shall be accomplished by vapor degreasing, immersion or spray application of alkaline or emulsion cleaners, steam, or high pressure water jetting.
   b. Mechanical Cleaning and Descaling – Mechanical cleaning is the removal of surface contamination, exogenous iron and rust. Mechanical descaling is the removal of oxide films resulting from high temperature processes such as heat treatment and welding from the surface of stainless steel. Mechanical cleaning and descaling shall be accomplished by abrasive bead blasting but may also include a combination of sanding, grinding, and power brushing to provide a surface that is smooth, uniform and free from all foreign matter, weld slag, corrosion, coatings, heat tint, discoloration, and mill scale. Grinding wheels and sanding tools should not contain iron, iron oxides, zinc or other materials that could contaminate the stainless steel surface. Abrasive blasting materials shall be unused glass beads or iron-free silica or alumina sand. Blasting equipment should not have been previously used for cleaning carbon steel or other materials containing free iron. All surfaces shall be wiped clean following mechanical cleaning.
   c. Post Cleaning Inspection – Post treatment inspection of the part shall exhibit a clean, bright and uniform surface with no signs of etching or pitting from the abrasive blasting procedure. All traces of oxide films from high temperature processes shall have been removed.
   d. Testing – The passivated part shall be tested for the presence or absence of free iron with a solution of potassium ferricyanide as defined in Verification Test Practice E, ASTM A967. The test solution shall be mixed and used within 24-hours or less and applied with sterile cotton swabs.
   e. Protection – Protection shall be provided by applying shrink wrap to all parts of the equipment sufficient to prevent exposure of passivated surfaces to contaminants during handling, shipping and installation. Protected equipment shall be tagged with highly visible warning signs stating the equipment has been passivated and shall only be opened by authorized personnel. Equipment arriving at the project site without proper protection will require retesting for the presence of free iron and re-passivation if free iron is detected.

2. Assembly of equipment following passivation – If assembly of bolted parts is required following passivation, it shall be done at the manufacturing facility under clean conditions such that the parts will not be contaminated with exogenous iron or iron compounds. Equipment requiring assembly shall be re-wrapped sufficient to prevent exposure of passivated surfaces to contaminants during handling, shipping and installation and tagged with warning signs.

2.05 EQUIPMENT FEATURES

A. Shafted Screw Conveyor:

1. The shafted screw conveyor shall be provided as a continuous, full length rotor with flights. The screw conveyor shall not be provided in sections.
2. Spiral flights and rotor shall be cold-formed from Type 304L stainless steel plate, minimum 3/16-inch thick and with a minimum hardness of 175 Brinnell. The spiral flights shall be fastened to the rotor by full depth continuous welds on both sides of the flight.
3. Rotor shall be designed with sufficient diameter and wall thickness to limit deflection to a maximum of 1/16-inch between any two bearing support points.
4. The torsional rating of the auger flighting shall exceed the torque rating of the drive motor at 150% of its nameplate horsepower. The "spring effect" of the spiral shall not exceed + 0.16” per foot of length at maximum load conditions. The minimum outer spiral thickness shall be 0.75”.
5. The spiral flighting shall be formed in sections from one continuous flat bar and shall be concentric to within +0.125”. Sectional flighting formed from plate shall not be permitted.
6. Spirals should conform to CEMA 300 as published by the Conveyor Equipment Manufacturers Association for US standard conveyors.
7. Stuffing boxes with packing material shall be provided at the drive end of the conveyor to prevent leakage between the shaft and the trough end plate. Provide a packing ring to allow adjustment to tighten the packing against the shaft.
8. Shaft bearings shall be provided at both ends of the conveyor. Additional bearings at intermediate locations will be determined by the Manufacturer. Bearings shall be double pillow block type, sized for the thrust loads, and mounted outside of the conveyor and accessible for maintenance. At the drive end of the conveyor, mount bearing housing outboard of the stuffing box assembly with sufficient clearance to permit removal and replacement of the packing material without removing the bearing. Provide bearing lubrication fittings in easily accessible locations; utilize stainless steel tubing where necessary. Bearings shall be sized to provide a L-10 bearing life of 100,000 hours.
9. The connection of the spiral to the drive system shall be through a flanged connection plate that is welded to the spiral forming a smooth and continuous transformation from the flange plate to the spiral. The drive shaft shall have a mating flange and shall be bolted to the spiral connection plate. A gland packing ring consisting of two Teflon fiber packing rings shall seal the drive shaft at its penetration through the end plate.

B. Conveyor Trough:

1. The conveyor trough shall be U-shaped and to the dimensional standards of CEMA 300 and enclosure classification IIE.

2. The conveyor trough shall be equipped with inlet and discharge openings as shown on the Drawings. Inlet opening shall be flanged and designed to connect to the slide gate frame. Discharge openings shall be flanged suitable for connection to the flange of the outlet chute. Interconnecting devices such as chutes and slide gates shall be fabricated from the same grade of material as the troughs and with a gauge thickness to suit the application requirements.
3. Troughs shall be designed without the use of steel hold down bars. For pushing drive conveyors, hold-down guide liners mounted in the trough sides above the design load fill level are acceptable providing they do not interfere with the flow of conveyed product.
4. The conveyor shall be provided with a bolted cover. Covers shall be manufactured in maximum 4 foot sections. Quick opening covers shall be bolted to prevent access during operation. Each conveyor shall be fixed with warning labels to call for lock out – tag out of the electrical system before the covers are removed. Inspection hatches or sample ports with finger guards will be provided at a minimum of 2 locations along the conveyor.
5. The troughs shall have removable end plates to facilitate installation and removal of the spiral from the ends of the troughs.

C. Drive Unit:
1. The screw conveyor shall be driven by a reversible constant-speed gear reducer motor drive unit. Direct coupling of the gear reducer/motor drive unit to the end flange of the conveyor will not be acceptable.
2. In the event of a prolonged power failure or emergency system shutdown the drive system shall be designed, at a minimum, to start the conveyor from a dead stop with the trough filled at 2 X the design load for loads designed up to 67% fill rate and 1.5 X for loads designed exceeding 67% fill rate.
3. Drive motors shall be a minimum of 5 HP and shall meet the requirements of Section 43 05 21.
4. Gears shall be AGMA Class II, single or double reduction, helical gear units with high capacity roller bearings. Bearings shall be designed for the thrust loads from the fully loaded startup condition and shall have an AFBMA B-10 life of 50,000 hours.
5. The gear reducer will be air-cooled unit with no auxiliary cooling requirement and be sized with a torque service factor of 1.5 times the absorbed power or 1.1 times the motor nameplate, at the driven shaft speed, whichever is greater.

D. Slide Gates and Actuators:
1. Slide gates shall be installed at the transfer point between the existing screw conveyor and the new screw conveyor. Slide gates shall be installed as close to the bottom of the trough of the existing conveyor as possible to minimize bridging.
2. Location of the slide gate shall be field verified by the contractor and coordinated during construction to determine.
3. Contractor shall determine the requirements necessary to connect the new cake collection screw conveyor to the existing cake transfer screw. Discharge chutes shall meet the requirements as stated in this Section.
4. The slide gate opening shall be at least the full width of the conveyor trough. The slide gates shall be fabricated of Type 316L stainless steel with UHMW PE seal, all minimum 3/16" thickness. The UHMW PE shall have a machined groove to accept the gate blade and give a positive seal.

5. Each slide gate shall be provided with a electric actuator sized to move the slide gate from the fully closed position to the fully open position and back to fully closed.Open/close time shall be adjustable.
    a. Actuators shall be double acting (air to open, air to close) with bearing surfaces and the inside cylinder wall and guides coated with a permanent, dry-film lubricant and corrosion inhibitor.

E. Conveyor Supports:
1. Supports for the conveyor shall be as indicated on the Reference Drawings. Contractor may propose alternative designs complying with seismic design requirements specified in Section 01 73 24 and at no additional cost to the Owner. Design shall be based on a completely filled trough plus dead load of the conveyor. Supports shall be fabricated from Type 304L stainless steel.

F. Control and Safety Features:
1. The conveyor drive unit shall be equipped with a zero speed motion failure alarm unit mounted external to the conveyor to detect spiral failure.
2. Furnish a cable operated OSHA safety stop switch with continuous cable run on both sides of the conveyor. The trip switch shall immediately stop the conveyor when the switch is actuated. Provide normally closed, 120-volt contacts for the interlocking circuit.
3. Provide torque and temperature protection for the motor.
4. Provide a single NEMA 4X junction box on each gate for connection of field-installed conduit and wiring. Provide conduit and wiring mounted on the gate frame from the junction box to each device mounted on the gate. Provide terminal strips mounted within the junction box for connection of field wiring.

2.06 SPARE PARTS

A. Tag and store as specified in Section 43 05 11.

B. Provide the following spare parts:
1. One packing gland set.
2. One motor.
3. One motor starter.
4. One gearbox.
5. One complete liner set.
6. One spare auger.
7. Five spare fuses of each size and type.
8. Two spare relays of each size and type.
9. Any special tools required for disassembly.

PART 3 EXECUTION

3.01 SHIPMENT, PROTECTION AND STORAGE

A. Contractor shall be responsible for field verifying dimensions, including the size of doors and wall openings that may be utilized to get the equipment within the building. The equipment shall be shipped from the Manufacturer's facility in components such that the largest equipment component can be brought inside the dewatering facility through the existing openings in the walls or through the access doors without structural modifications or disassembly of the equipment on-site. Equipment shipment and protection shall conform to the requirements specified in Section 01 66 00.

3.02 INSTALLATION

A. Proper handling shall incorporate all practices described in Section 8.5 – Protection of Cleaned Surfaces, ASTM A380. Passivated parts contaminated due to improper handling and installation will require retesting for the presence of free iron and re-passivation if free iron is detected.

B. Screw conveyance equipment shall be installed in accordance with the Manufacturer's installation instructions, and in compliance with all OSHA, local, state, and federal codes and regulations.

C. Manufacturer shall provide 8-hours of services of a factory trained Factory Representative to check installation and start-up. Factory Representative shall have complete knowledge of proper installation, operation, and maintenance of equipment supplied.

D. Factory Representative shall inspect the final installation, work with the electrical subcontractor and/or the supplier of the local control panels, supervise the start-up test of the equipment, and provide written certification of the acceptability of the installation.

3.03 PROJECT-SPECIFIC INSTALLATION REQUIREMENTS

A. Contractor shall confirm all elevations and dimensions in the field and provide information to the Manufacturer to allow development of a custom designed and custom fabricated transfer screw conveyor system. Detailed layout and fabrication drawings submitted for review shall indicate field measured elevations and dimensions.

B. The existing screw conveyors shall be modified by cutting an opening in the bottom of each trough and installing a custom designed and fabricated connection for the transfer screw conveyor. Grind edges of openings smooth. Field weld connection piece to existing conveyor trough using seal welds. Pickle and passivate areas of the stainless steel surfaces that are affected by the welding. Manufacturer to provide recommended methods and products.

3.04 TESTING

A. Testing and commissioning of the equipment shall be performed in accordance with Section 01 45 23 and 01 91 00 and the requirements of this Section. Contractor shall coordinate testing and commissioning such that the Manufacturer's Factory Representative and the electrical subcontractor are present simultaneously to check the proper functioning of local control panels and proper integration with the existing SCADA system as specified in Section 01 79 00.

3.05 TRAINING

A. The Contractor shall provide two 2-hour instructional sessions conforming to the requirements specified in Section 01 79 00 and taught by the Factory Representative.

B. The training sessions shall include preventive maintenance requirements, overhaul and troubleshooting instructions, and normal operating practices.

END OF SECTION

SECTION 41 22 23.19

MONORAIL HOISTS

PART 1 GENERAL

1.01 DESCRIPTION

A. Scope:

1. This section specifies a monorail system complete with hoist, trolley, associated drive unit and pendant controls, for installation on the upper level of the solids processing building for maintenance of the screw press dewatering system.
2. This section speficies the general requirements of the monorail system. The drawings indicated two basis on designs based on the selected dewatering system selected. The length of the support tracks and location of the track switches vary based on the selected dewatering system. Coordination and mounting of the monorail system is dependent on the selection of the dewatering system and can deviate from the information within this specification.

B. Equipment List:

1. Equipment numbers are as follows:

Item	Equipment No.
Screw Press 1 Monorail	72HST2630
Screw Press 2 Monorail	72HST2730
Screw Press 3 Monorail	72HST2830

1.02 RELATED SECTIONS

A. Related Sections:

1. This section contains specific references to the following related sections. Additional related sections may apply that are not specifically listed below. Where a referenced document cites other standards, such standards are included as references under this section if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.
   a. Section 01 11 80 - Environmental Conditions
   b. Section 01 33 00 – Submittal Procedures
   c. Section 01 78 23 - Operation and Maintenance
   d. Section 01 99 90 - Reference Forms
   e. Section 05 05 20 - Anchor Bolts
   f. Section 26 09 16 - Electrical Controls And Relays
   g. Section 40 67 00 - Control System Equipment Panels And Racks
   h. Section 43 05 11 - General Requirements for Equipment
   i. Section 43 05 21 - Common Motor Requirements for Equipment

1.03 REFERENCE STANDARDS

A. ASME HST-4 - Performance Standard for Overhead Electric Wire Rope Hoists; Current Edition.

B. ASTM A36/A36M - Standard Specification for Carbon Structural Steel; 2019.

C. CMAA - Crane Manufacturers Association of America, Inc.; Current Standards.

D. HMI - The Hoist Manufacturers Institute, Inc.; Current Standards.

1.04 DEFINITIONS (NOT USED)

1.05 ADMINISTRATIVE REQUIREMENTS

A. Coordination
   1. See Section 01 12 16: Work Sequence.

B. Unit Responsibility
   1. The Contractor shall assign unit responsibility as specified in Section 43 05 11-1.02 Unit Responsibility to the monorail hoist equipment manufacturer for all equipment specified in this section.

1.06 SUBMITTALS

A. Action Submittals
   1. Comply with procedures described in Section 01 33 00.
   2. Submit a completed Certificate of Unit Responsibility attesting that the Contractor has assigned and the manufacturer accepts unit responsibility in accordance with the requirements of this section and Section 43 05 11-1.02: Unit Responsibility. No other submittal material will be reviewed until the certificate has been received and found to be in conformance with these requirements.
   3. Submit a copy of this specification section and those listed below, with addendum updates included, with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements.
      a. Section 43 05 11: General Requirements for Equipment
      b. Section 43 05 21: Common Motor Requirements for Equipment
   4. Use check-marks (✓) to denote full compliance with a paragraph as a whole. Underline and denote deviations with a number in the margin to the right of the identified paragraph. Remaining portions of the paragraph not underlined signify the Contractor's compliance with the specifications. Submit a detailed, written justification for each requested deviation. Failure to submit a copy of the marked-up specification sections, along with justification(s) for all requested deviations from the specification requirements, with the submittal, shall be sufficient cause for rejection of the entire submittal with no further consideration.

5. Provide a copy of the contract document control diagrams and process and instrumentation diagrams relating to the submitted equipment. Include addendum updates applying to the equipment in this section, marked to show specific changes necessary for the equipment proposed in the submittal. If no changes are required, mark the drawing or drawings with "no changes required". Failure to include copies of relevant drawings with the submittal shall be cause for rejection of the entire submittal with no further review.
6. Provide drawings showing general dimensions and confirming the size of monorail motors, drives, and specified appurtenances; construction details of equipment (including bearings); wiring diagrams; and weight of equipment.
7. Provide motor submittal information specified in Section 43 05 21 and conforming to paragraph 2.08: Motor and Drive Unit.

B. Informational Submittals
1. Comply with procedures described in Section 01 33 00.
2. Provide performance guarantee as specified in paragraph 1.07: Quality Assurance.
3. Provide operation and maintenance information as specified in Section 01 78 23.
4. Provide motor product data as specified in Section 43 05 21.
5. Provide certification of satisfactory factory testing of each unit as specified in paragraph 1.07: Quality Assurance. Include copies of test logs and resulting performance curves.
6. Provide operating and maintenance information as specified in Section 01 78 23 including manufacturer's warranties specified in paragraph 1.02 Warranty and Section 01 78 23.
7. Submit Installation Certification Form 43 05 11-A as specified in paragraph 3.04.
8. Submit Training Certification Form 43 05 11-B as specified in paragraph 3.04.

C. Closeout Submittals
1. Comply with procedures described in Section 01 33 00.
2. Provide warranties as specified in paragraph 1.09.
3. Spare parts
   a. Not used.

1.07 QUALITY ASSURANCE

A. Factory Testing
1. Shall be performed according to the manufacturer's standard test procedures.
2. Provide certified test results as an Informational Submittal.

B. Performance Guarantee
1. Manufacturer must guarantee the pump performance specified in paragraph 2.03 Performance/Design Criteria. The guarantee shall be in writing, signed by an officer of the manufacturing corporation, and notarized. Under no circumstances shall deviations from the specified operating conditions result in overload of the driver furnished with the equipment, nor shall such deviations result in power requirements greater than the driver's nameplate (1.0 service factor) rating.

1.08 DELIVERY, STORAGE, AND HANDLING

A. Comply with procedures described in Section 01 66 00.

1.09 WARRANTIES (NOT USED)

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. The following candidate manufacturers are capable of producing equipment and/or products satisfying the requirements of this section. The manufacturer's standard product may require modification to conform to specified requirements.

B. Candidate Manufacturers
   1. Harrington Hoists
   2. Yale Hoist
   3. ACCO Hoist
   4. Or approved Equal

2.02 TYPE

A. The units shall be underhung, close headroom, single girder monorail. Hoists shall be of the heavy-duty, electric wire rope type with electric driven trolley.

B. The trolleys shall be four wheel type with tracks and appurtenances in accordance with the drawings, Section 05 10 00, and as specified herein.

C. Hoist and trolley motor controller drive types can be single-speed, two-speed or variable speed as specified in paragraph 1.02 Operating Requirements.

2.03 PERFORMANCE/DESIGN CRITERIA

A. All equipment provided under this section shall be suitable for Class-A, L4, N1 of service as defined by CMAA standards with the heavy-duty hoist suspended from its trolley.
   1. Monorail beams, complete with connections to the structural support systems, splices and runway stops, shall be furnished by the crane manufacturer. Monorail beam shall be designed by a registered civil or structural engineer in accordance with the hoist manufacturer's recommendations. Load bearing connections shall be provided at each beam or girder and where necessary to limit deflection to less than 1/450 of span.
   2. Load carrying parts, except structural members and hoisting ropes, shall be designed so that the calculated static stress in the material, based on rated bond, shall not exceed 20 percent of the assumed ultimate strength of the material. Structural members shall be designed in accordance with the latest edition of the CMAA specifications. The rated capacity load plus the weight of the bottom block divided by the number of parts of hoisting rope shall not exceed 20 percent of the published breaking strength of the rope.

3. The hoists and trolleys shall be electrified and the drives shall be reversible. Control of motions shall be from a traveling pushbutton pendant on the hoist with strain reliever. All controls shall be clearly marked with etched or engraved nameplates. An emergency stop switch shall be provided on the pendant.
4. Hoist control shall have separate spring-loaded (deadman) pushbuttons for each direction of the trolley travel. The control shall contain an inching control with a separate set of pushbuttons and allow repetitive motion in either direction. The pushbutton controlling opposite motions shall be mechanically interlocked to avoid being depressed simultaneously.

B. Operating Requirements:
1. Operating requirements shall be as follows:

Parameter	72HST2630 72HST2730 72HST2830
Capacity, tons	1.5
Vertical lift, feet	20
Approximate hoist lift speed, fpm	10
Approximate trolley speed, fpm	40
Maximum hoist motor horsepower	7.5
Maximum trolley horsepower	0.75
Environment	Unclassified (by ventilation)
Hoist and trolley Controller Type	2 step FVR]

2. Hook approach distances and high hook position shall be as shown on the drawings. The Contractor is advised to examine the drawings for interferences and obstructions which might impose additional limitations upon the equipment.

C. Unit Responsibility:
1. The Contractor shall assign unit responsibility as specified in Section 43 05 11-1.02 Unit Responsibility to the monorail hoist equipment manufacturer for all equipment specified in this section.

2.04 MATERIALS

A. Materials for monorail hoists are specified below.

Component	Material
Runway beam	Steel, ASTM A36
Bottom tees	Manganese steel, 225 Brinell hardness
Trolleys, wheels, hook	Steel, ASTM A36
Wire rope	Stainless Steel

2.05 EQUIPMENT

A. Monorail Beam:

1. Monorail beam shall be specially fabricated composite beams comprised of top flange, web and hardened steel bottom tee section, continuously welded to the web. The bottom tee shall be shaped to provide a running surface for the end trucks.

B. End Truck:

1. The monorail end truck shall carry the rated load between the end truck wheels while the rated load is lifted at one end of the monorail. End truck wheel bases shall be 1/8 of the span or greater.
2. A rubber bumper shall be mounted on each end of the end truck. Safety lugs shall be provided to limit drop of the end truck to 1 inch or less in the event of wheel or axle failure.
3. Bearings shall be fitted with seals to exclude dust and moisture and shall be lubricated for life.
4. Wheels shall be alloy steel or cast iron with tread surfaces hardened to 375 to 425 Brinell. Axles and wheels shall be removable without disturbing other truck elements.

C. Trolley:

1. Trolley wheels shall be hardened steel, mounted on permanently lubricated antifriction bearings. The trolleys shall be motorized and shall be designed for lug connection of the hoist.

D. Hoist:

1. Hoist shall be close headroom. The hoisting drums shall be grooved and designed for one layer of wire rope. Hoist gearing shall be heat-treated hardened steel, running in an oil bath. Gear bearings shall be the oil-lubricated antifriction type, and all bearings shall be designed for a Class M2 (20,000 hour) bearing life.
2. The hoist shall contain an automatic electromechanical type brake designed for long life and positive stopping. The hoist shall contain two brakes designed for long life and positive stopping. One brake shall stop the motor rotation. A second “load brake” shall be applied automatically on lowering and require the motor to drive the load down. Both motor and mechanical load brakes shall be capable of holding 125 percent of load independently of each other.
3. A geared upper and lower limit switch and a plugging upper limit switch shall be provided to assure safe operation and positive stopping under all conditions. The geared limit switch shall automatically stop the motor and engage the hoist brake when the hook reaches either it’s upper or lower limit of travel. The hoist shall be provided with a load-limiting device adjusted to 110 percent of rated capacity.
4. Each load hook shall be mounted on ball thrust bearings to swivel without twisting the wire rope. The lifting tackle shall be of the safety type, and the hooks shall be of hardened steel equipped with a safety catch. Sheaves shall be properly guarded and shall be heavy pattern, deep flanged and properly grooved. Sheaves shall be either bronzed bushed or fitted with ball bearings and supported on fixed pins.

E. Track Switches
   1. Provide electrical track switches at locations shown in the drawings.
   2. Switches shall be 30 degrees, unless otherwise specified.
   3. Switch direction shall be left handed unless otherwise specified.

F. Motor:
   1. Motors shall be special purpose 1750 rpm, 460 volt, 3 phase, totally enclosed, non-ventilated (TENV) epecially designed for hoist service and provided with an inching circuit. Brakes shall be solenoid actuated. Hoist motor bearings shall be grease lubricated.
   2. Trolley motions shall be through reversible electric motor. Trolley motors shall drive the trolley through enclosed gear reducers with dual output shafts to solid rubber tire driving wheels spring mounted on the underside of the monorail. Gear reducers shall be enclosed heavy-duty helical type, of a self-lubricating design with antifriction bearings.
   3. AC squirrel cage motors shall be designed and insulated for variable speed (frequency) drives (VFD) use with a 100% duty rating.

G. Electrical Equipment and Controls:
   1. General:
      a. All electrical and control equipment shall comply with the requirements of Section 26 09 16 Electrical Devices and Section 40 67 00.
         1) The monorail hoist manufacturer shall furnish and mount all electrical equipment on the hoist including motors, control and conduit. Conductors may be removed for shipment. Hoist wire shall be furnished by the hoist manufacturer, cut to length and installed as far as practical for shipment.
   2. Power Supply:
      a. Power supply for hoist equipment will be 460V, 3 phase, 60 Hertz. The Contractor shall provide the power feeder with a local disconnect switch to the hoist controller. Control power transformers shall be provided as necessary by the manufacturer.
   3. Controllers:
      a. Control equipment, including relays, pushbuttons, transformers, and interconnecting wiring shall be provided by the monorail hoist supplier and housed in NEMA 7 enclosures.

2.06 PRODUCT DATA

A. The following information shall be provided:
   1. Operating and maintenance information in accordance with Section 01 78 23.
   2. Factory tested certification.
   3. Installation Certification Section 43 05 11-Form A.
   4. Instruction Certification Section 43 05 11-Form B.

PART 3 EXECUTION

3.01 INSTALLATION

A. Manufacturer shall test the equipment in accordance with industry standards and federal regulations prior to shipment of the equipment. The monorail, trolley, and hoist shall be completely assembled and no load run tested prior to shipment to the job site. Monorail hoist shall be disassembled to the least amount possible for shipment. The trolley and hoist shall be installed at the location shown and in accordance with the manufacturer's recommendations.

B. The monorail system shall be installed and tested by the Contractor with the assistance of a factory-trained representative. The installation shall be certified on Form 43 05 11-A specified in Section 01 99 90.

3.02 TESTING

A. After completion of installation, the monorail hoist, trolley, and hoist shall be completely tested to ensure compliance with the performance requirements as specified. As a minimum, testing shall be by operating the equipment through a complete lift and lowering cycle and through a complete travel of the monorail to determine that the equipment performs smoothly and safely without failure.

B. Such tests shall be carried out with the hoisting equipment loaded as near to the specified capacity as possible. Any defects shall be corrected or replaced immediately by the Contractor and at no expense to the Owner. Final OSHA inspection, load tests, all other testing, and certification shall be at the Contractor's expense.

3.03 TRAINING

A. The Contractor shall provide the services of a factory-trained manufacturer’s representative to provide training of the Owner’s personnel in the proper operation and maintenance of the equipment.

B. Prior to final acceptance, the Contractor shall furnish the Construction Manager with two copies of the manufacturer’s certifications (Section 01 99 90-Form 43 05 11-B). Training shall be performed in accordance with Section 01 78 23.

3.04 MANUFACTURER’S REPRESENTATIVE

A. The Contractor shall include in his bid all costs associated with providing the services of the manufacturer’s field representative for checking, aligning testing, placing in operation, and Owner training.

3.05 USE BY CONTRACTOR

A. Any hoist used by the Contractor shall be repaired, repainted and otherwise refurbished to like-new condition prior to its acceptance. The Contractor assumes all responsibility for operation and maintenance until the monorail and hoist has been accepted.

END OF SECTION

SECTION 43 05 11

GENERAL REQUIREMENTS FOR EQUIPMENT

PART 1 GENERAL

1.01 DESCRIPTION

A. Scope:
   1. This section specifies general requirements which are applicable to all mechanical equipment.

1.02 QUALITY ASSURANCE

A. Arrangement:
   1. The arrangement of equipment shown on the drawings is based upon information available to the Owner at the time of design and is not intended to show exact dimensions conforming to a specific manufacturer. The drawings are, in part, diagrammatic, and some features of the illustrated equipment installation may require revision to meet actual submitted equipment installation requirements; these may vary significantly from manufacturer to manufacturer.

B. References:
   1. This section contains references to the documents listed below. They are a part of this section as specified and modified. Where a referenced document cites other standards, such standards are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.
   2. Unless otherwise specified, references to documents shall mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid (or on the effective date of the Agreement if there were no Bids). If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued. Where document dates are given in the following listing, references to those documents shall mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, has been discontinued or has been replaced.

Reference	Title
ABMA Std 9	Load Ratings and Fatigue Life for Ball Bearings
ABMA Std 11	Load Ratings and Fatigue Life for Roller Bearings
ANSI B1.1	Unified Inch Screw Threads (UN and UNR Thread Form)
ANSI B1.20.1	Pipe Threads, General Purpose (Inch)
ANSI B16.1	Gray Iron Pipe Flanges and Flanged Fittings, (Classes 25, 125, and 250)
ANSI B18.2.1	Square and Hex Bolts and Screws (Inch Series)
ANSI B18.2.2	Square and Hex Nuts (Inch Series)
ISO 1940-1	Mechanical Vibration – Balance Quality Requirements for Rotors in a Constant (Rigid) State: Part 1: Specification and Verification of Balance Tolerances

C. Unit Responsibility:

1. The unit responsibility manufacturer shall coordinate selection, coordinate design, and shall provide all mechanical equipment assembly components such that all equipment components furnished under the specification for the equipment assembly, and all equipment components specified elsewhere but referenced in the equipment assembly specification, is compatible and operates reliably and properly to achieve the specified performance requirements. Unless otherwise specified, the unit responsibility manufacturer shall be the manufacturer of the driven component equipment in the equipment assembly. The unit responsibility manufacturer is designated in the individual equipment specifications found elsewhere in this project manual. Agents, representatives or other entities that are not a direct division of the driven equipment manufacturing corporation shall not be accepted as a substitute for the driven equipment manufacturer in meeting this requirement.

D. Unit responsibility for related components in a mechanical equipment assembly does not require or obligate the unit responsibility manufacturer to warranty the workmanship or quality of component products not manufactured by them. Where an individual specification requires the Contractor to furnish a certificate from a unit responsibility manufacturer, such certificate shall conform to the content, form and style of Form 43 05 11-C specified in Section 01 99 90, shall be signed by an officer of the unit responsibility manufacturer's corporation and shall be notarized. No other submittal material will be processed until a Certificate of Unit Responsibility has been received and has been found to be satisfactory. Failure to provide acceptable proof that the unit responsibility requirement has been satisfied will result in withholding approval of progress payments for the subject equipment even though the equipment may have been installed in the work.

E. NOT USED

PART 2 PRODUCTS

2.01 FLANGES AND PIPE THREADS

A. Flanges on equipment and appurtenances provided under this section shall conform in dimensions and drilling to ANSI B16.1, Class 125. Pipe threads shall conform in dimension and limits of size to ANSI B1.1, coarse thread series, Class 2 fit.

B. Threaded flanges shall have a standard taper pipe thread conforming to ANSI B1.20.1. Unless otherwise specified, flanges shall be flat faced.

C. Flange assembly bolts shall be heavy pattern, hexagonal head, carbon steel machine bolts with heavy pattern, hot pressed, hexagonal nuts conforming to ANSI B18.2.1 and B18.2.2. Threads shall be Unified Screw Threads, Standard Coarse Thread Series, Class 2A and 2B, ANSI B1.1.

2.02 BEARINGS

A. Unless otherwise specified, equipment bearings shall be oil or grease lubricated, ball or roller type, designed to withstand the stresses of the service specified. Each bearing shall be rated in accordance with the latest revisions of ABMA Methods of Evaluating Load Ratings of Ball and Roller Bearings. Unless otherwise specified, equipment bearings shall have a minimum L-10 rating life of 50,000 hours. The rating life shall be determined using the maximum equipment operating speed.

B. Grease lubricated bearings, except those specified to be factory sealed and lubricated, shall be fitted with easily accessible grease supply, flush, drain and relief fittings. Extension tubes shall be used when necessary. Grease supply fittings shall be standard hydraulic alemite type.

C. Oil lubricated bearings shall be equipped with either a pressure lubricating system or a separate oil reservoir type system. Each oil lubrication system shall be of sufficient size to safely absorb the heat energy normally generated in the bearing under a maximum ambient temperature of 60 degrees C and shall be equipped with a filler pipe and an external level indicator gage.

D. All bearings accessible to touch, and located within 7 feet measured vertically from floor or working level or within 15 inches measured horizontally from stairways, ramps, fixed ladders or other access structures, shall either incorporate bearing housings with sufficient cooling to maintain surface temperature at 65 degrees C or less for continuous operation at bearing rated load and a 50 degrees C ambient temperature or shall be provided with appropriate shielding shall be provided that will prevent inadvertent human contact.

2.03 NOT USED

2.04 NOT USED

2.05 COUPLINGS

A. Unless otherwise specified in the particular equipment sections, equipment with a driver greater than 1/2 HP, and where the input shaft of a driven unit is directly connected to the output shaft of the driver, shall have its two shafts connected by a flexible coupling which can accommodate angular misalignment, parallel misalignment and end float, and which cushions shock loads and dampens torsional vibrations. The flexible member shall consist of a tire with synthetic tension members bonded together in rubber. The flexible member shall be attached to flanges by means of clamping rings and cap screws, and the flanges shall be attached to the stub shaft by means of taper lock bushings which shall give the equivalent of a shrunk-on fit. There shall be no metal-to-metal contact between the driver and the driven unit. Each coupling shall be sized and provided as recommended by the coupling manufacturer for the specific application, considering horsepower, speed of rotation, and type of service.

B. Where torque or horsepower capacities of couplings of the foregoing type is exceeded, Thomas-Rex, Falk Steel Flex, or equal, couplings will be acceptable provided they are sized in accordance with the equipment manufacturer's recommendations and sizing data are submitted. They shall be installed in conformance to the coupling manufacturer's instructions.

2.06 GUARDS

A. Exposed moving parts shall be provided with guards which meet all applicable OSHA requirements. Guards shall be fabricated of 14-gage steel, 1/2-13-15 expanded metal screen to provide visual inspection of moving parts without removal of the guard. Guards shall be galvanized after fabrication and shall be designed to be readily removable to facilitate maintenance of moving parts. Reinforced holes shall be provided. Lube fittings shall be extended through guards.

2.07 CAUTION SIGNS

A. Equipment with guarded moving parts which operates automatically or by remote control shall be identified by signs reading "Caution - Automatic Equipment May Start At Any Time". Signs shall be constructed of fiberglass material, minimum 1/8 inch thick, rigid, suitable for post mounting. Letters shall be white on a red background. The sign size and pattern shall be as shown on the drawings. Signs shall be installed near guarded moving parts.

2.08 NOT USED

2.09 NAMEPLATES

A. Nameplates shall be provided on each item of equipment and shall contain the specified equipment name or abbreviation and equipment number. Equipment nameplates shall be engraved or stamped stainless steel and fastened to the equipment in an accessible and visible location with stainless steel screws or drive pins.

2.10 LUBRICANTS

A. The Manfuacturer shall provide for each item of mechanical equipment a supply of the required lubricant adequate to last through the specified commissioning period. Lubricants shall be of the type recommended by the equipment manufacturer and shall be products of the Owner's current lubricant supplier. The Contractor shall limit the various types of lubricants by consolidating them, with the equipment manufacturer's approval, into the least number of different types. The Contractor shall provide the Owner with three copies of a list showing the required lubricants, after consolidation, for each item of mechanical equipment. The list shall show estimated quantity of lubricant needed for a full year's operation, assuming the equipment will be operating continuously.

2.11 NOT USED

2.12 SPARE PARTS

A. Spare parts, wherever required by detailed specification sections, shall be stored in accordance with the provisions of this paragraph. Spare parts shall be tagged by project equipment number and identified by part number, equipment manufacturer, and subassembly component (if appropriate). Spare parts subject to deterioration, such as ferrous metal items and electrical components, shall be properly protected by lubricants or desiccants and encapsulated in hermetically sealed plastic wrapping. Spare parts with individual weights less than 50 pounds and dimensions less than 2 feet wide, or 18 inches high, or 3 feet in length shall be stored in a wooden box with a hinged wooden cover and locking hasp. Hinges shall be strap type. The box shall be painted and identified with stenciled lettering stating the name of the equipment, equipment numbers, and the words "spare parts." A neatly typed inventory of spare parts shall be taped to the underside of the cover.

PART 3 EXECUTION

3.01 GENERAL

A. Installation of equipment accessories included in this section shall be as recommended by the equipment manufacturer unless otherwise specified in the individual equipment specification section.

END OF SECTION

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SECTION 43 05 13

RIGID EQUIPMENT MOUNTS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: This Section specifies requirements for rigid equipment mounts. Rigid equipment mounts consist of equipment pads, equipment anchors, and mounting plates (baseplates, soleplates, or fabricated steel frames) set in grout.

B. Conform to the requirements specified in the Equipment Mounting Schedule (Part 4 of this Section) or equipment mounting configuration requirements specified in individual equipment specifications. Where equipment mounting requirements are not specifically identified, the default mounting configuration for equipment consists of Pad Anchored Equipment Pads per Standard Detail D01007 with adhesive dowels anchoring the equipment pad to the foundation, equipment and driver mounted on a common mounting plate, mounting plate leveled within 0.005 inch/foot, equipment anchored to the equipment pad with cast-in-place equipment anchors per Standard Detail D01002, equipment anchor sleeve length is 10 times the bolt diameter, and the mounting plate is grouted in position using non-shrink grout.

C. If a conflict exists between this Section and requirements of individual equipment manufacturers, the more restrictive requirements shall prevail.

D. Requirements for non-rigid equipment mounts (vibration isolation systems) are specified in the associated equipment specification. Furnish rigid equipment mounts conforming to the requirements of this Section for the equipment pad and other equipment mounting components supporting the vibration isolation system.

1.02 RELATED SECTIONS

A. This Section contains specific references to the following related sections. Additional related sections may apply that are not specifically listed below.

1. Section 01 61 45 – Area Exposure Designations
2. Section 01 73 24 - Structural Design and Anchorage Requirements for Nonstructural Components and Non-Building Structures
3. Section 01 99 90 - Reference Forms
4. Section 03 60 00 – Grouting
5. Section 05 05 20 – Anchor Bolts
6. Section 09 90 00 – Painting and Coating
7. Section 43 05 11 – General Requirements for Equipment
8. Section 43 05 14 – Machine Alignment
9. Section 43 05 17 – Vibration and Critical Speed Limitations

1.03 REFERENCES

A. This Section contains references to the following documents. They are a part of this Section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this Section as if referenced directly. In the event of conflict between the requirements of this Section and those of the listed documents, the requirements of this Section prevail.

Reference	Title
ACI 318, Appendix D	Building Code and Commentary, Anchorage to Concrete
HI 14.3	Rotodynamic Pumps –for Design and Application
HI 14.4	Rotodynamic Pumps –for Installation, Operation and Maintenance
API RECOMMENDED PRACTICE 686	Recommended Practices for Machinery Installation and Installation Design
ASCE 7	Minimum Design Loads and Associated Criteria for Buildings and Other Structures
ASME B1.1	Unified Inch Screw Threads (UN and UNR Thread Form)
ASTM E329	Inspection and Testing Agencies for Concrete, Steel, and Bituminous Materials as Used in Construction
ASTM F593	Stainless Steel Bolts, Hex Cap Screws, and Studs
ASTM F1554	Anchor Bolts, Steel, 36, 55 and 105 ksi Yield Strength
MIL-PRF-907E	Anti-Seize Thread Compound, High Temperature
SSPC	Society for Protective Coatings Specifications, Vol. 2
IBC	International Building Code (including local amendments)

1.04 DEFINITIONS

A. Terminology used in this Section conforms to the following definitions:

1. Baseplate: A mounting plate configured with a top plate and a perimeter edge of the mounting plate that is below the top plate. Baseplates have a cavity between the top plate and a horizontal plane at the bottom edge of the perimeter of the mounting plate.
2. Soleplate: A machined or pre-formed mounting plate with a uniform horizontal surface across the entire underside of the mounting plate, excepting shear lugs/keys, grout pour holes, vent holes, and attachment hardware (nuts, bolts, tapped holes, etc.). Soleplates have a top plate but lack the perimeter bottom edge that extends below the underside of the top plate that is a defining feature of baseplates.
3. Fabricated Steel Frame: An equipment mounting plate constructed of rolled steel shapes and plates welded into a frame. Fabricated steel frames do not have top plates.
4. Equipment Pad: Concrete foundation (block or slab) supporting and elevating mounting plates above the supporting structural floor slab or local grade.
5. Mounting Pads: Milled/machined areas of baseplates, soleplates, and fabricated steel frames where the feet or mounting surfaces of mounted equipment and drivers are bolted to the baseplate, soleplate, or fabricated steel frame.
6. Leveling Blocks: Steel blocks temporarily placed under baseplates, soleplates, or fabricated steel frames at leveling positions (at equipment anchors) for the purpose of leveling baseplates, soleplates, or fabricated steel frames prior to grouting.

7. Shims: Thin stainless steel plates of uniform thickness used for fine adjustment of level. Shims are used on top of leveling blocks for mounting plate leveling or used between equipment drivers and baseplates, soleplates, or fabricated steel frames for equipment alignment.
8. Wedges: Pairs of uniformly tapered metal blocks that are stacked with the tapered surfaces reversed (relative to the other wedge) so that the top and bottom surfaces of the wedges are parallel. Wedges are used between equipment pads and baseplates, soleplates, or fabricated steel frames for the purpose of leveling mounting plates.
9. Mounting Stud: Threaded rod or bolts anchored to baseplates, soleplates, or fabricated steel frames for the purpose of mounting equipment or ancillary devices onto baseplates, soleplates, or fabricated steel frames.
10. Reinforcement Dowels or Reinforcement Hooks: Steel reinforcement rods embedded in concrete, across a cold joint, for the purpose of transferring loads or force across the joint.
11. Leveling Position: A location on the top of a concrete equipment pad where leveling tools and equipment will be temporarily installed or used for the purpose of leveling baseplates, soleplates, and fabricated steel frames prior to grouting.
12. Grout Manufacturer: Refers to the manufacturer of the grout product used for installation of rigid equipment mounts.
13. Grout Manufacturer's Technical Representative(s): Refers to the technical representative(s) of the Grout Manufacturer. The Grout Manufacturer's Technical Representative shall not be an employee of the Contractor.

1.05 ADMINISTRATIVE REQUIREMENTS

A. Pre-installation Meetings:
   1. Conduct a pre-installation meeting with the Construction Manager's representative prior to installation of equipment mounts.
   2. Schedule a pre-installation meeting for the equipment mounts associated with each system or group of identical equipment items.
   3. Where equipment anchors are cast in the floor slab or foundation, schedule the pre-installation meeting prior to pouring the floor slab or foundation.

1.06 SUBMITTALS

A. Action Submittals:
   1. Procedures: Section 01 33 00.
   2. A copy of this Section, including addendum updates, (referenced sections need not be included for this Section) with each paragraph check-marked to indicate compliance or marked to indicate requested deviations from specification requirements. Check marks denote full compliance with a paragraph as a whole. Underline each deviation and denote with a number in the margin to the right of the identified paragraph, referenced to a detailed written explanation of the reasons for requesting the deviation. Mark copies of this Section with the specification number and equipment number for inclusion (filing) with submittal materials furnished for individual equipment specifications.

3. Name, employer, and a copy of the employee's Qualified Millwright card or other equivalent certificate of journeyman qualifications for millwrights who will install rigid equipment mounts, as specified in paragraph 3.02, Leveling.
4. Certificates or other documentation issued by the epoxy grout manufacturer that demonstrates that the grout manufacturer's technical representative has been factory trained on installation of epoxy grout for equipment mounts, as specified in paragraph 1.07 Quality Control by Contractor.
5. List of Contractor's equipment installation staff that have completed epoxy grout manufacturer's grout installation training specified in paragraph 3.03, Manufacturer's Services.
6. Shop drawings for equipment pads, equipment anchors, and baseplate, soleplate or fabricated steel frame depict size and location of equipment pads and reinforcement; equipment drains; equipment anchor, size, location, and projection; expansion joint locations; grout formwork; elevation of top of grout and grout thickness; elevation of top of baseplate, soleplate, or mounting block; size and location of electrical conduits; and any other equipment mounting features embedded in equipment pads. Shop drawings for equipment pads, equipment anchors, and baseplate, soleplate, or fabricated steel frames to be numbered and marked (specification number and equipment number) for inclusion (filing) with the associated equipment submittal requirements.

B. Informational Submittals:
1. Procedures: Section 01 33 00
2. Submit equipment anchor calculations demonstrating compliance with paragraph 2.04, Equipment Anchor Design. Submit equipment anchor calculations with submittal information specified in the associated equipment specification.
3. Results of grout strength tests, as specified in paragraph 3.02, Grouting.
4. Completed Rigid Equipment Mount Installation Inspection Checklist Forms (43 05 13-A), as specified in paragraph 3.03, Manufacturer's Services.

1.07 QUALITY ASSURANCE

A. Quality Control By Contractor:
1. Except where union rules require installation by another trade, all machinery to be mounted and leveled by journeyman millwrights.
2. Epoxy grout installation performed by employees that have completed the epoxy grout manufacturer's grout installation training specified in this Section.
3. Provide the services of an independent testing laboratory that complies with the requirements of ASTM E329. Testing laboratory to sample and test materials installed as part of rigid equipment mounts specified in this Section. Testing laboratory services costs borne by the Contractor.
4. Where epoxy grout is specified for bedding mounting plates, furnish the services of a grout manufacturer's technical representative who has been factory trained by the grout manufacturer. The grout manufacturer's technical representative performs training and quality control for epoxy grout installation for rigid equipment mounts as specified in paragraph 3.03, Manufacturer's Services.

B. Special Inspection for Equipment Anchors:
   1. Equipment anchors shall comply with special inspection requirements specified in Section 05 05 20.

PART 2 PRODUCTS

2.01 GENERAL

A. Configure rigid equipment mounts as specified in the Equipment Mounting Schedule (See Part 4 of this specification) or as specified in individual equipment specifications. Equipment mounting configuration requirements in individual equipment specifications govern over configuration requirements specified in the Equipment Mounting Schedule. In the absence of equipment mounting configuration requirements in either of these locations, mount equipment per the default requirements specified in paragraph 1.01.

B. Pumps installed in accordance with this Section, HI 14.3, and HI 14.4.

2.02 MATERIALS FOR EQUIPMENT MOUNTING

A. Equipment pads: Reinforced concrete as specified in Standard Details D01007

B. Mounting Plates: Cast iron, cast steel, plate steel, fabricated steel frame, polymer concrete, or FRP as specified in the equipment specification.

C. Grout type for equipment mounting as specified in the Equipment Mounting Schedule or in individual equipment specification.
   1. Epoxy Grout for Equipment Mounting: Where epoxy grout is specified in the Equipment Mounting Schedule or in individual equipment specifications, provide Epoxy Grout for Equipment Mounting as specified in Section 03 60 00. Where the term epoxy grout is used in the context of details and specifications for equipment mounting it means Epoxy Grout for Equipment Mounting as specified in Section 03 60 00.
   2. Cementitious Nonshrink Grout: Where non-shrink grout is specified in the Equipment Mounting Schedule or in individual equipment specifications, Cementitious Non-shrink Grout, specified in Section 03 60 00, may be used for setting bearing surfaces of baseplates, soleplates, or fabricated steel frames. Where the term non-shrink grout or cementitious grout is used in the context of details and specifications for equipment mounting it means Cementitious Non-shrink Grout as specified in Section 03 60 00.

D. Equipment anchors: Materials per the following table and per the area exposure condition where the equipment is installed. Section 01 61 45 specifies area exposure conditions.

Area Exposure	Equipment Anchor Materials
Indoor, Dry	Carbon Steel, ASTM F1554, Grade 36, weldable per S1 for threaded rod
Indoor, Wet	Galvanized Carbon Steel, ASTM F1554, Grade 36, weldable per S1 for threaded rod
Outdoor	304 Stainless, ASTM F593, Cond. CW
Submerged, Immersed	316 Stainless, ASTM F593, Cond. CW

Area Exposure	Equipment Anchor Materials
Process Corrosive	316 Stainless, ASTM F593, Cond. CW
Chemical Corrosive	316 Stainless, ASTM F593, Cond. CW

E. Anchor sleeves: Flexible polyurethane foam, steel cylinder/tubes, or corrugated/ribbed plastic sleeves.

F. Epoxy Primer: High-strength, lead free, chrome free, rust inhibiting two-component epoxy primer specifically designed for use on metal substrates and in conjunction with epoxy grout. Bond strength to sandblasted metal not less than 1500 psi.
   1. ITW Performance Polymer MS-7CZ primer
   2. Approved equal.

G. Anti-seize/Anti-galling compound: Molybdenum disulfide and graphite combination in aluminum complex base grease conforming to MIL-PRF-907E.
   1. Jet Lube 550 by Jet Lube, Inc.
   2. E-Z Break by LA-CO
   3. or approved equal.

2.03 EQUIPMENT PADS

A. Minimum dimensions for equipment pads are shown on structural drawings where a minimum equipment pad mass is required for vibration dampening/control.

B. Equipment Pad Drainage:
   1. Furnish equipment pads with 2-inch drains.
   2. Locate equipment pad drains at drainage outlets from equipment or mounting plates
   3. Route equipment drainage outlets or mounting plate drainage outlets to equipment pad drains
   4. Route equipment pad drains to the floor drainage collection system.
   5. Drainage piping for equipment pads shall be routed below the finished floor elevation.
   6. Exposed drain lines mounted on the floor are not acceptable.

2.04 EQUIPMENT ANCHORS

A. Equipment Anchors:
   1. All thread rod with heavy hex welded nuts, heavy hex bolts, post-installed anchors (wedge, sleeve, undercut, expansion, and adhesive anchors), or adjustable canister anchors as specified in the Equipment Mounting Schedule or in individual equipment specifications.
   2. Bolt length as required for the specified embedment and sleeve length. Reduce equipment anchor sleeve length as necessary to fit within finished height of equipment pad if equipment pad height is insufficient to provide specified equipment anchor sleeve length. Unified Coarse Thread Series per ASME B1.1.
   3. Post-installed anchors (wedge, sleeve, undercut, expansion, and adhesive anchors) conforming to the requirements of Section 05 05 20.

4. Adjustable canister anchors consist of cast-in-place pre-manufactured adjustable anchor inserts. Provide a minimum of 6 inches of vertical bolt height adjustment and lateral adjustment of the anchor bolt while maintaining the anchor bolt in a true vertical orientation.
    a. Jakebolts as manufactured by Unisorb
    b. Heavy Duty Adjustable Anchors as manufactured by Deco
    c. Rowan Adjustable Canister Anchor Bolt
    d. or approved equal.

B. Equipment Anchor Design:
1. Comply with Local Governing Building Code for equipment anchor size, embedment, and edge distance. Provide equipment anchors that are sufficient to resist the maximum lateral and vertical forces specified in Specification Listing Seismic/Structural Requirements For The Project, Section 01 73 24.
2. Resistance to lateral (horizontal) loads based on the static friction between the mounting plate and its supporting grout pad. Include the clamping force applied by equipment anchors and the weight of the equipment for calculating static friction resistance to lateral loads. Do not include lateral (shear) loading on equipment anchors or adhesion between mounting plates and supporting grout in lateral loading resistance calculations.
4. Furnish equipment anchor calculation submittals for all equipment unless one of the following exceptions is applicable:
    a. The importance factor, I_p, for the equipment is equal to 1.0, flexible connections are provided for all electrical and mechanical connections to the equipment, the center of mass of the equipment is less than 48 inches above the floor when it is mounted or attached to the structure, and the equipment weighs less than 400 pounds.
    b. The importance factor, I_p, for the equipment is equal to 1.0, flexible connections are provided for all electrical and mechanical connections to the equipment, and the equipment weighs less than 20 pounds.
5. Equipment anchor calculations sealed by a registered structural or civil engineer licensed in the State of Washington.

C. Equipment Anchor Tension:
1. Unless alternate bolt torque/tension requirements are specified by the equipment manufacturer, tighten equipment anchors to provide a final clamping force that produces a tensile stress of 15,000 psi in each equipment anchor. Tighten adjustable canister anchors to the manufacturer's maximum safe working load. Tighten post-installed anchors to manufacturer's recommendations.
2. Bolt torque values required to produce the specified bolt tension based on well lubricated plain finish national coarse thread bolts are presented in the following table. Revise bolt torque values per equipment manufacturer's recommendations for alternate thread patterns, thread lubrication, bolt material, or bolt finish.

Bolt Diam. (in)	3/8	1/2	5/8	3/4	7/8	1	1-1/8	1-1/4	1-1/2
Final bolt torque for 15,000 psi bolt stress (ft*lbs)	8	15	30	50	80	125	180	250	400

3. Prior to leveling and grouting mounting plates, pull test grouted equipment anchors (standard detail D01003) to the values specified in the following table.

Anchor Diam. (in)	3/8	1/2	5/8	3/4	7/8	1	1-1/8	1-1/4	1-1/2
Pull test load (kips)	2.1	3.8	6.1	9.1	13	17	22	28	43

D. Anchor Sleeves:
   1. Provide sleeves for equipment anchors as specified in the Equipment Mounting Schedule or in individual equipment specifications.
   2. Adjust equipment anchor length/embedment depth shown in Standard Detail D01002 and Standard Detail D01003 if sleeves are not required.
   3. Sleeves may be installed at the Contractor's option if not specified in the Equipment Mounting Schedule or in individual equipment specifications provided they do not interfere with specified embedment lengths.
   4. Fill steel cylinders/tubes and ribbed plastic sleeves with a flexible room temperature vulcanizing (RTV) sealant prior to embedment/installation.

2.05 MOUNTING PLATES

A. General:
   1. Round edges of surfaces of baseplates, soleplates, and fabricated steel frames that bear on grout to a radius of not less than 0.25 inch.
   2. Round perimeter corners of baseplates, soleplates, or fabricated steel frames to a radius of not less than 2.0 inches to avoid producing stress risers on the grouted foundation.
   3. Provide grout pouring holes (minimum 4 inches in diameter for epoxy grout, minimum 2.5 inches in diameter for cementitious non-shrink grout) and air release holes in all baseplates and soleplates.
   4. Provide grout relief or vent holes (minimum 1 inch in diameter) in all baseplates and soleplates.
   5. Drill mounting holes for equipment anchors through baseplates, soleplates, and fabricated steel frames. Open slots or burned out holes for equipment anchors are not permitted.
   6. Provide acorn nuts welded to the underside of the baseplate or soleplate or nuts welded to the underside of the baseplate or soleplate and plugged with cork, plastic plugs or grease where terminations to baseplates and soleplates are required.
   7. Where fasteners terminate only into the baseplate, soleplate, or fabricated steel frame, threaded lengths (tapped or embedded in mounting plates) shall be not less than the bolt diameter.
   8. Where baseplates, soleplates, or fabricated steel frames are leveled using jackscrews, tap jackscrew threads in thickened pads or otherwise in sufficient metal to provide ease in adjusting level.
   9. Mill mounting pads and/or mounting surfaces of baseplates, soleplates, and fabricated steel frames flat and coplanar within 0.0005 inch per foot in all directions after all welding and stress relieving.
   10. Pre-grout baseplates prior to milling.

11. Baseplates, soleplates, and fabricated steel frames provide common support for the equipment and driver (and flywheel, if one is specified).
12. For equipment with drivers 20 horsepower and greater, provide transverse alignment (horizontal) positioning jackscrews for alignment of equipment drivers on horizontal surfaces of baseplates, soleplates, and fabricated steel frames.
13. Provide alignment/positioning jackscrews in perpendicular directions in a horizontal plane at the mounting position for each corner or foot of the equipment driver. (Additional jackscrews provided for transverse alignment of the flywheel, if flywheels are specified in the equipment specification.)
14. Where specified in individual equipment specifications; baseplates, soleplates, and fabricated steel frames fitted with RK Fixators as manufactured by Unisorb, or approved equal.
    a. Fixators installed at mounting surfaces for drivers.
    b. Fixators consist of a three-piece wedge leveling adjustment device incorporating a spherical washer assembly to provide true level height adjustment at each mounting surface for the equipment driver.

B. Baseplates:
1. Baseplates may be welded steel, cast steel, or cast iron with thickened mounting pads for bolting equipment to the baseplate.
2. Provide internal stiffeners on all cast and fabricated baseplates. Stiffeners designed to allow free flow of grout from one section of the baseplate to another.
3. Provide a minimum 2 inches high by 6 inches wide opening in cross bracing and stiffeners for grout flow between sections of the baseplate.
4. All welds continuous and free from skips, blowholes, laps and pockets.
5. Pre-grout baseplates at the factory after all welding has been completed and prior to machining the mounting pads on the baseplate. Pre-grout baseplates in the field if they have not been pre-grouted at the factory. Remove the equipment from the baseplate, invert the baseplate, and pre-grout as specified in this Section.
6. Prior to pre-grouting, sandblast the underside of baseplates to white metal per SSPC SP-5.
7. Complete pre-grouting within 8 hours of sandblasting.
8. Fill the underside of the baseplate to the bottom edges of the baseplate.
9. Seal cast iron baseplates to prevent surface bleeding prior to shipment to the project site.

PART 3 EXECUTION

3.01 PREPARATION

A. Concrete Equipment Pad Preparation:
1. Roughen the top of the equipment pad after the concrete has reached its 28-day compressive strength.
2. Remove all laitance and defective or weak concrete.
3. Roughen surface profile to 0.25 inch amplitude, minimum.
4. Expose broken aggregate without dislodging unbroken aggregate from the cement matrix and without fracturing concrete and aggregate below the concrete surface.

5. Roughen using a light-duty (15 pounds or less), hand-held chipper with a chisel type tool.
6. Abrasive blast, bush-hammer, jack hammers with sharp chisels, heavy chipping tools, or needle gun preparation of concrete surfaces to be grouted are not acceptable.
7. Demonstrate removal of defective or weak concrete to the Construction Manager prior to leveling.
8. Chip the surface of the concrete such that the final elevation of the equipment pad provides the grout manufacturer's recommended thickness between the surface of the equipment pad and the lower baseplate flange, underside of the soleplate, or underside of the fabricated steel frame.
9. Remove all dust, dirt, chips, oil, water, and any other contaminants and protect the surface with plastic sheeting until grout is installed.
10. Protect concrete equipment pad surfaces that have been finished smooth and level for use as leveling positions. Protect from damage during chipping activities. Alternatively, leveling positions may be restored on chipped surfaces. Restore leveling positions by installing leveling blocks or leveling plates for jackscrews on a high compressive strength epoxy putty (Philadelphia Resins, Phillybond Blue 6A, or equal). Leveling blocks and leveling plates installed level on the epoxy putty.

B. Grout Form Construction:
1. Design forms for a minimum of 6 inches hydrostatic head above the final elevation of the grout and manufacturer's recommendations for form edge clearance for intended pour scheme, but not less than two inches.
2. Install grout expansion joints at 4 to 6 foot intervals, perpendicular to the centerline of baseplates. Design expansion joints in accordance with the grout manufacturer's written instructions.
3. Coat forms with three coats of paste wax on all areas of the forms that will be in contact with the grout.
4. Wax forms before assembly.
5. Prevent accidental application of wax to surfaces where the grout is to bond.
6. Remove any foreign material, such as oil, sand, water, wax, grease, etc., from concrete surfaces that will contact grout before forms are installed.
7. Forms must be liquid tight. Seal any open spaces or cracks in forms, or at the joint between forms and the foundation using sealant, putty, or caulking compound.
8. Chamfer vertical and horizontal edges of the grout with 45-degree chamfers as specified in equipment pad details. Locate 45-degree perimeter chamfer strips at the final elevation of the grout.
9. Match chamfers in concrete portions of the equipment pad.
10. Install block outs at all leveling positions to allow removal of leveling equipment and leveling nuts to be backed off after the grout has cured.
11. Coat jackscrews with a light oil or other acceptable bond-breaking compound prior to grouting.
12. Seal equipment anchor sleeves to protect the sleeved length of the anchor from contact with grout.
13. Wrap exposed portions of equipment anchors with duct tape to protect them from grout splatter and to prevent bonding to grout.

C. Mounting Plate Preparation:

1. Roughen the underside of soleplates and fabricated steel frames and wipe with a residue-free solvent as recommended by the epoxy primer manufacturer before placement of the baseplate, soleplate, or fabricated steel frames on the equipment pad for leveling. Roughen surfaces of mounting plates that will be in contact with grout by power tool cleaning. Cleaning performed by power wire brushing, power sanding, power grinding, power tool chipping or power tool descaling. Impart a minimum profile of 1.0 mil.
2. Prior to placement on the equipment pad for leveling, roughen exposed grout surfaces of pre-grouted baseplates and wipe with a residue-free solvent as recommended by the manufacturer of the epoxy grout used for pre-grouting.
3. Prepare the underside of corrosion-resistant FRP baseplates and polymer concrete baseplates per the baseplate manufacturer's recommendations and prior to placement of the baseplate on the equipment pad for leveling.
4. Grouting for installation of mounting plates on equipment pads completed prior to connecting any field piping or electrical and instrumentation systems.
5. Unless the Construction Manager accepts an alternate installation procedure in writing, baseplates, soleplates, and fabricated steel frames leveled and grouted with the equipment removed.

3.02 INSTALLATION

A. Leveling:

1. Except where union rules require installation by another trade, all equipment and machinery mounted and leveled by a Qualified Millwright.
2. Use precision surveying equipment for leveling.
3. Machinists' spirit levels will not be permitted for leveling purposes for any baseplate, soleplate, or fabricated steel frame with a plan dimension greater than 4 feet.
4. Baseplates, soleplates, and fabricated steel frames leveled to the tolerance specified in the Equipment Mounting Schedule, in the individual equipment specification, or as otherwise required by the equipment manufacturer, if more stringent.
5. Apply an anti-seize or anti-galling compound, specified in paragraph 2.02, to all equipment anchor threads prior to beginning baseplate, soleplate, or fabricated steel frame leveling.
6. Level all baseplates, soleplates, and fabricated steel frames against steel surfaces (jackscrew plates, leveling blocks, leveling nuts, support plates, or other steel surfaces). Use of other materials for leveling purposes is strictly and specifically prohibited.
7. Use stainless steel leveling blocks and shims, steel wedges, or jackscrews bearing on leveling plates.
8. Leveling nuts may be used for leveling baseplates, soleplates, and fabricated steel frames weighing less than 200 pounds (inclusive of the weight of the equipment if leveled with the equipment on the mounting plate).
9. Leveling blocks shall be stainless steel, 4 inches square and 1.5 inches thick with an open-ended slot terminating in the center for the equipment anchor.
10. Machine leveling blocks flat on all horizontal surfaces and place under the baseplate or soleplate at each equipment anchor.

11. Provide pre-cut stainless steel shims, slotted for removal after grouting. Coat leveling blocks and shims with a light oil just prior to beginning the leveling and grouting work. Place shims so the tabs on the shims are easily accessible.
12. Clamp baseplates, soleplates, or fabricated steel frames in position (after leveling) by installing the equipment anchor nuts and washers.
13. Apply bolt tension to fix the position of mounting plates during grouting (30 to 60 percent of the final clamping force applied to clamp the mounting plate to the equipment pad).
14. Prior to grouting, verify that the correct level and position of the baseplate, soleplate, or fabricated steel frame has been maintained after clamping it to the equipment pad.

B. Grouting:
1. Adjust ambient temperature to maintain mounting plate, foundation, and grout temperatures to grout manufacturer's recommended temperature.
2. Mix grout for equipment mounting in accordance with the grout manufacturer's written recommendations.
3. Place epoxy grout using a method that avoids air entrapment.
4. Place grout at one end of the baseplate or soleplate and work grout toward the opposite end to force the air out from beneath the baseplate or soleplate.
5. Pour grout through a head box into grout pouring holes.
6. When the head box is moved to the next grout hole, place a 6 inch standpipe over the grout hole and fill with grout.
7. Pour grout to the top of the lower flange of the perimeter I-beams or C-channel of fabricated steel frames.
8. Pour grout at least 0.125 inch but not more than 0.5 inch above the bottom or underside of the perimeter edge of a baseplate or soleplate.
9. Use of vibrating tools and/or jarring (rapping or tapping) forms to facilitate grout flow is not permitted during placement of epoxy grout.
10. Never allow the grout in the head box to fall below the top of the baseplate or soleplate once the grout has made contact with the baseplate or soleplate.
11. Grout placement applied in one continuous pour, until all portions of the space beneath the baseplate, soleplate, or fabricated steel frame have been filled.
12. Prepare subsequent batches of grout prior to depleting the preceding batch.
13. Maintain grout height in standpipes after the space under the baseplate, soleplate, or fabricated steel frame has been filled.
14. When the grout has started to take an initial set (typically this is determined by a noticeable increase in temperature and no flow of grout at the vent holes) remove the standpipes and clean excess grout from all surfaces.
15. Check for leaks throughout grout pours. Repair leaks immediately to prevent formation of voids.
16. Check baseplate, soleplate, or fabricated steel frame level and elevation before the grout sets.
17. Cure grout in accordance with the grout manufacturer's written instructions.

18. Collect at least one grout sample from each grout pour. Where specified in the individual equipment specifications, collect a grout sample from the grout pour for each equipment pad.
    a. Place samples in a cylinder of sufficient size to yield three 2-inch cubes as test samples.
    b. Label samples with project name, date, time, the equipment number, and ambient temperature at the time of placement.
    c. Place samples next to the foundation of the equipment being grouted and cure for 48 hours.
    d. Test grout samples in accordance with the grout manufacturer's recommendations.
    e. Grout samples tested by the independent testing laboratory specified in paragraph 1.07 Quality Control by Contractor.
    f. Report test results directly to the Construction Manager.

C. Completion:
    1. Upon acceptance by the Construction Manager and the equipment manufacturer's representative and after the grout has reached sufficient strength, remove grout forms and block outs at leveling positions. Remove leveling blocks and shims or wedges and support plates. Back off leveling nuts and jack screws to allow the grout to fully support the baseplate, mounting block, or soleplate. Take care not to damage the grout during removal of extended shimming material or leveling equipment and tools.
    2. Tighten equipment anchor nuts using calibrated indicating torque wrenches, to develop the full bolt tension specified in paragraph 2.04 Equipment Anchor Tension.
    3. Tighten equipment anchor nuts in increments of not more than 25 percent of the final torque value in an alternating pattern to avoid stress concentration on the grout surface. After tightening equipment anchor nuts to final values, apply additional wax, grease, or mastic to all exposed portions of the equipment anchor beneath the baseplate, soleplate, or mounting block.
    4. After applying additional wax or mastic to exposed portions of equipment anchors and tightening to final torque values, fill and point block outs (pockets) for access to leveling nuts, leveling blocks, shims, or wedges with the grout material installed under baseplates, soleplates, or fabricated steel frames. Remove jackscrews and fill holes in the baseplate, soleplate, or fabricated steel frame with a flexible sealant (silicone rubber) or a short cap screw.
    5. Check for baseplate, soleplate, or fabricated steel frame movement (soft foot) by individually loosening and re-tightening each equipment anchor. Measure and record vertical movement at each equipment anchor during loosening and retightening. Measure vertical movement using a magnetic-based dial indicator on the baseplate, soleplate, or fabricated steel frame referenced to the epoxy grout surface of the equipment pad, or other approved method. Vertical movement exceeding 25 micrometers (0.001 inch) indicates a soft foot condition. Soft foot conditions are sufficient cause for removal and reinstallation of grout and baseplates, soleplates, or fabricated steel frames.

6. Check for grout voids by tapping along the upper surfaces of the baseplate, soleplate, or mounting block. Mark grout voids. A grout void is sufficient cause for removal and reinstallation of grout and baseplate, soleplate, or fabricated steel frame. At the discretion of the Construction Manager, grout voids may be repaired as specified in Chapter 5, Section 3.16 of API RP 686.

D. Piping Connections:
   1. Anchor piping connecting to flexible connections and/or expansion joints such that the intended function of these connections/joints is maintained in the piping system without imposing strain on the equipment connections.
   2. Where an equipment manufacturer's installation requirements include a rigid connection between the machine and connecting piping systems, delete any flexible coupling (including equipment connection fittings) shown on the drawings and install the equipment in the following manner, in lieu of installing the flexible coupling:
      a. Install equipment pad as shown in the detail specified in the Equipment Mounting Schedule or in the individual equipment specification.
      b. Install the baseplate, soleplate, or fabricated steel frame supporting the equipment and grouted in place as specified in this Section.
      c. Install and align the equipment in place as specified in Section 43 05 14.
      d. Install and align piping between equipment connections and field piping without welding one of the joints for one section of pipe between the equipment connection and the field piping and all valving. All flanged joints bolted up and pressure-tested.
      e. All piping must be fully supported by supports designed to accept their full weight and thrust forces.
      f. Install the final section of piping. Align the final section of pipe with the equipment and field connections without the use of jacks, chain falls, or other devices to force it into alignment.
      g. Do not weld the final piping joints until after the previous steps have been completed and accepted by the Construction Manager.

3.03 FIELD QUALITY CONTROL

A. Manufacturer's Services
   1. Epoxy Grout Training: Prior to commencing rigid equipment mount installation work on equipment pads, furnish the services of a grout manufacturer's technical representative to conduct a training school for the workers who will be using epoxy grout for rigid equipment mount installations. Epoxy grout training school duration to be not less than 4 hours duration and covers all aspects of using the products, including form construction for each equipment installation, surface preparation, mixing, application, void prevention/elimination, and clean up. This requirement does not relieve the Contractor of overall responsibility for this portion of the work. Epoxy grout manufacturer to furnish a list of school attendees who have been satisfactorily trained to perform epoxy grout installation for equipment mounting.

2. Epoxy Grout Quality Control: The epoxy grout manufacturer's technical representative provides quality control services for equipment mounted with epoxy grout. The epoxy grout manufacturer's technical representative must be present (on site) to inspect and verify that the installation personnel have successfully performed surface preparation, epoxy grout application, and Quality Control Inspection in accordance with these specifications for a representative portion of the epoxy grout installation work.
3. Epoxy grout manufacturer's technical representative performs the following services for at least one rigid equipment mount installation for each equipment type and size installed with epoxy grout:
    a. Inspect ambient conditions during various phases of epoxy grouting installation for conformance with the epoxy grout manufacturer's requirements.
    b. Inspect the surface preparation of concrete substrates onto which epoxy grout materials are to be applied. Inspect surface for conformance to the specified application criteria, including but not limited to substrate profile, degree of cleanliness, and moisture.
    c. Inspect the surface preparation of the metallic substrates onto which the epoxy primer is to be applied.
    d. Inspect the epoxy-primed metallic substrate for coverage and adhesion.
    e. Inspect preparation and application of epoxy grout form work for conformance to the specifications and manufacturer's recommendations for form edge clearance.
    f. Inspect and record that the "pot life" of epoxy grout materials is not exceeded during installation.
    g. Inspect epoxy grout for cure.
    h. Inspect and record that localized repairs made to grout voids conform to the specification requirements.
    i. Conduct a final review of completed epoxy grout installation for conformance to these specifications.
    j. Attest to conformance of the Contractor's work by signing appropriate entries in the "Rigid Equipment Mount Inspection Checklist," Form 43 05 13-A in Section 01 99 90.

B. Training and quality control by the grout manufacturer's technical representative is not required for rigid equipment mounts installed with cementitious non-shrink grout.

3.04 FINAL INSPECTION

A. The Construction Manager will conduct a final inspection with the Contractor for conformance to requirements of this Section.

PART 4 EQUIPMENT MOUNTING SCHEDULE (NOT USED)

END OF SECTION

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SECTION 43 05 14

MACHINE ALIGNMENT

PART 1 GENERAL

1.01 SUMMARY

A. This section specifies requirements for alignment of directly coupled mechanical equipment weighing 1000 pounds or more and/or greater than 5 horsepower furnished or modified under this contract.

B. Equipment direct coupled to the motor with drivers 5 horsepower and less and belt or chain driven machinery are specifically exempted from the requirements of this section.

C. Separately mounted equipment connected by offset universal joints are exempted from the offset and angularity requirements, but all units must be installed and leveled as specified in this section and referenced sections.

1.02 RELATED SECTIONS

A. Section 43 05 11 – General Requirements for Equpment

B. Section 43 05 13 – Rigid Equpment Mounts

C. Section 43 05 17 – Vibration and Critical Speed Limitations

1.03 REFERENCES

A. This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.

B. Unless otherwise specified, references to documents shall mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid (or on the effective date of the Agreement if there were no Bids). If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued. Where document dates are given in the following listing, references to those documents shall mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, discontinued or replaced.

Reference	Title
ANSI/ASA S2.75 Part 1	Shaft Alignment Methodology, Part 1: General Principals, Methods, Practices, and Tolerances
ANSI/ASA S2.75 Part 2	Shaft Alignment Methodology, Part 2: Vocabulary
ANSI/ASA S2.75 Part 3	Shaft Alignment Methodology, Part 3: Alignment of Vertically Oriented Rotating Machinery

Reference	Title
Shaft Alignment Handbook	Shaft Alignment Handbook, Third edition, John Piotrowski, Marcel Dekker Inc.

1.04 DEFINITIONS

A. Follow definitions as defined in ANSI/ASA S2.75, Parts 1, 2, and 3.

1.05 QUALITY ASSURANCE

A. General:
   1. All equipment shall be aligned using laser alignment equipment to the tolerances specified by the subject equipment manufacturer or the criteria specified in this section, whichever is more stringent.

B. Alignment Criteria:
   1. Unless otherwise specified by more stringent manufacturer's requirements or the the detailed equipment specification:
      a. Meet the level, flatness, and coplanarity limits in ANSI/ASA S2.75, Part 1, Table 1, for equipment bases and sole plates.
      b. Comply with shaft runout tolerances in ANSI/ASA S2.75, Part 1, Table 2,
      c. Conduct a test for soft foot prior to aligning machines.
         1) Soft foot (machine frame distortion) shall be not more than 2.0 mils for any speed.
      d. Align all process equipment, including pumps, blowers, turbines, and similar machines to meet the Precision Tolerance Range in Tables 3 and 4 of ANSI/ASA S2.75, Part 1.

C. Qualifications:
   1. All alignment work shall be performed by millwrights trained in the use of the laser alignment equipment by the manufacturer.

1.06 SUBMITTALS

A. Provide in accordance with Section 01 33 00:
   1. Action Submittals:
      a. Prior to testing, provide a Testing Plan Report identifying, for each piece of equipment, testing location and passing measurement values for each location and test type.
      b. Summary report verifying compliance with the alignment criteria as set forth in paragraph 1.06.B. Include hard copy of all alignment records, signed and dated by the technician performing the work.
      c. Electronic files, including both a summary (pdf) file and files native to the alignment software used for completing the work specified in this section.
      d. Qualifications of the alignment technician.
         1) Millright training
         2) Training certification from the laser alignment equipment manufacturer

PART 2 PRODUCTS

2.01 EQUIPMENT

A. Laser alignment equipment shall be:
   1. Easy-Laser®
   2. PrufTechnik
   3. ACOEM,
   4. or approved equal.

B. Alignment equipment used to perform the work required under this section shall employ laser alignment techniques to achieve the required tolerances. The equipment shall be computer based and its software shall be compatible with current Windows® based spreadsheets and databases. The equipment shall employ a hand-held field computer using a graphic interface to determine actual alignment and necessary corrective action to bring equipment into required tolerance. The link between field measurement components and the computer shall be through cable, infrared, or wireless transmission.

PART 3 EXECUTION

3.01 GENERAL

A. After machine base grouting as specified in Section 43 05 13, align all machines mounted on baseplates or soleplates as specified in this section.

B. Alignment work shall be performed by journeyman millwrights skilled in this type of work under the supervision of a technician trained in the use of the laser alignment by the manufacturer or vendor of the alignment equipment. The use of untrained laborers, carpenters or apprentices for this work will not be acceptable.

C. Submit alignment report for each machine within 2-weeks of completing the alignment.

3.02 PROCEDURE

A. Sequence:
   1. Machines supported on integral feet or support pads shall be leveled, grouted and aligned in the following order: driven machine; intermediate bearings or machines; and driver. Under certain circumstances, such as a diesel engine driving a generator, it may be preferable to reverse this order and set the driver first. The Contractor shall submit a written request for a reversal of the alignment order to the Construction Manager and the Construction Manager must approve any change in alignment order in writing before it will be allowed.

B. Alignment:
   1. All machines shall be rough aligned without any connections to piping, electrical and instrumentation systems. Upon completion of all field connections, alignment shall be rechecked to demonstrate no change. If change has occurred, the Contractor shall eliminate any external forces affecting machine alignment.

2. Next, soft foot (machine frame distortion) shall be measured and brought to within the permissible tolerances. Thereafter, the alignment shall be rechecked and the alignment process repeated if necessary to bring all machinery to final alignment tolerances.

3.03 VERIFICATION

A. Factory Personnel:

1. Where required by other sections in this project manual, factory authorized installation technicians representing the equipment manufacturer shall witness final alignment work. After completion of all alignment work, acceptance of the work shall be documented in writing by factory authorized installation technicians.

END OF SECTION

SECTION 43 05 17

VIBRATION AND CRITICAL SPEED LIMITATIONS

PART 1 GENERAL

1.01 DESCRIPTION

A. This section specifies vibration and critical speed limitations for rotating mechanical equipment. Factory and/or field testing and vibration measurements shall be taken when specified in the individual equipment specification sections.

1.02 VIBRATION LIMITATIONS

A. General:
   1. Vibration frequencies shall span the range from 5.0 to 5000 Hz. Where specified, measurements shall be obtained while the installed equipment is operating within the specified speed range.

B. Centrifugal:
   1. Machines With Sleeve Bearings:
      a. Unless otherwise specified, centrifugal machines with sleeve bearing shafts shall not exhibit unfiltered RMS readings for vibration displacement in excess of the following:

Shaft speed range, rpm	Displacement, peak to peak, mils
Up to 900	3.5
901-1800	3.0
1801-3000	2.5
3001-4500	2.0
Above 4500	1.6

      b. Displacement measurements shall be taken radially on the shaft at two points at each bearing, except for well pumps which shall be measured at top of motor. Measuring points shall be 90 degrees apart.
   2. Machines with Antifriction Bearings:
      a. Unless otherwise specified, centrifugal machines with antifriction bearing shafts shall not exhibit unfiltered RMS readings for vibration velocity in excess of 0.12 inch per second. Velocity measurements shall be taken on one point of each bearing housing.

C. Positive Displacement Machines:
   1. Unless otherwise specified, positive displacement machines of the rotary, reciprocating and controlled volume types shall operate without any lateral or torsional vibration characteristics that may accelerate wear of the equipment. The Contractor shall provide manufacturer's certification that the manufacturer has inspected the machine under operating conditions and found it to comply with the requirements of this paragraph.

1.03 CRITICAL SPEED REQUIREMENTS

A. Unless otherwise specified, rotating mechanical equipment shall not exhibit critical speeds within the specified range of operating speeds. Critical speeds for equipment with rigid rotor systems shall be at least 20 percent greater than maximum operating speed. Critical speeds for equipment with flexible shaft-rotor systems shall be at least 15 percent below minimum operating speed and 20 percent above maximum operating speed.

PART 2 PRODUCTS

2.01 PRODUCT DATA

A. Manufacturer's certified data showing location of critical speeds in relation to operating speeds shall be provided as product data in accordance with Section 01 33 00.

PART 3 NOT USED

END OF SECTION

SECTION 43 05 21

COMMON MOTOR REQUIREMENTS FOR EQUIPMENT

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes:
   1. Squirrel cage type, AC induction motors, up to 500 HP, for up to 4 poles (3600 or 1800 rpm nominal), or up to 250 HP for over 6 poles (1200 rpm or slower) shall be per NEMA MG1, Small or Medium.
   2. Special purpose motors with features or ratings which are not specified herein, are specified in the particular equipment specifications.

1.02 RELATED SECTIONS

A. This section contains specific references to the following related sections. Additional related sections may apply that are not specifically listed below.
   1. Section 26 29 23 Variable Frequency Motor Controllers

1.03 REFERENCES

A. This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.

Reference	Title
ABMA 9	Load Ratings and Fatigue Life for Ball Bearings
ABMA 11	Load Ratings and Fatigue Life for Roller Bearings
IEEE 112	Standard Test Procedures for Polyphase Induction Motors and Generators
IEEE 841	Standard for Petroleum and Chemical Industry- Premium-Efficiency, Severe Duty Totally Enclosed Fan-Cooled (TEFC) Squirrel Cage Induction Motors - Up to and Including 500 HP
NEMA ICS 2	Industrial Control and Systems Controllers, Contactors and Overload Relays Rated Not More Than 2000 Volts AC or 750 Volts DC
NEMA 250	Enclosures for Electrical Equipment (1000 volts maximum)
NEMA MG 1	Motors and Generators
Department of Energy	Energy Policy and Conservation Act, Final Rules EERE-2010-BT-STD-0027-0117
UL 674	Electric Motors and Generators for Use in Division 1 Hazardous (Classified) Locations
UL 1004	Electric Motors

1.04 DEFINITIONS

A. Terminology used in this Section conforms with NEMA MG-1. Motors covered in this specification are those defined in NEMA MG1 as Small (Fractional) and Medium (Integral) AC induction motors.

1.05 ADMINISTRATIVE REQUIREMENTS

A. Unit Responsibility: Where Unit Responsibility is specified in the driven equipment sections of these specifications, the motor supplier shall coordinate with the provider of the driven equipment to verify that the motor provided under this section is fully compatible with and meets the specified performance requirements for that equipment.

1.06 SUBMITTALS

A. Action Submittals:
   1. Procedures: Section 01 33 00.
      a. Copy of this Section, with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements.
      b. Check-marks (✓) to denote full compliance with a paragraph as a whole. Underline deviations and denote by a number in the margin to the right of the identified paragraph. The remaining portions of the paragraph not underlined will signify compliance. Include a detailed, written justification for each deviation.
      c. Failure to include a copy of the marked-up specification sections with justification(s) for any requested deviation will cause rejection of the entire submittal with no further consideration.
   2. Motor Data Sheets specified in this Section and Division 01.
      a. Motors in conformance with IEEE 841: Manufacturers to complete IEEE Standard 841 Data Sheet for AC Induction Motors.
      b. Motors not in conformance with IEEE 841: Motor supplier to complete Form 43 05 21-A in Section 01 99 90 with required factory data.
      c. Motor Speed-Torque curve, where specified.
   3. Routine Factory test data for polyphase motors.
      a. High-potential test.
   4. Factory test data, from required dynamometer tests, where specified.
   5. Vibration level when measured in accordance with NEMA MG 1, for all IEEE 841 motors, and where elsewhere specified.
   6. Motor heating curve, where specified,
   7. Motor mounting, outline, dimensions, and weight.
   8. Motor bearing and winding RTDs (resistance temperature detector), where specified.
   9. Motor winding thermostat or thermistor, where specified.
   10. Motor winding space heaters, where specified.
   11. Motor nameplate data.

B. Informational Submittals:
   1. Procedures: Section 01 33 00 and 01 78 23.
   2. Submittal requirements for operation and maintenance manuals as per requirements of Section 01 78 23.

1.07 QUALITY ASSURANCE

A. Factory Testing:
   1. All polyphase motors shall be factory tested in conformance with routine tests per NEMA MG1 and IEEE 112. Provide the following tests:
      a. Measurement of winding resistance.
      b. No-load readings of current and speed at normal voltage and frequency.
      c. Current input at rated frequency with rotor at standstill.
      d. High potential test.

B. Where specified for use in corrosive or hazardous locations, motor testing shall additionally be per IEEE 841. Test report shall be certified by the motor manufacturer's test personnel and submitted to the Engineer.
   1. For motors larger than 100 horsepower, test and submit results for the following:
      a. Routine tests per NEMA MG1 and IEEE 112. Provide tests as noted in paragraph 1.07 Factory Testing. Test report shall be certified by the motor manufacturer's test personnel and submitted to the Engineer.
      b. For motors larger than 200 horsepower, efficiency and power factor by Test Method B, IEEE 112. Submit Form B and B-2.

1.08 DELIVERY, STORAGE AND HANDLING

A. Procedures shall be in accordance with Section 01 66 00.

1.09 SPECIAL WARRANTY

A. Submit warranties in writing to include 100 percent full payment coverage for parts and labor for repair or replacement of the motor (s) during the warranty period.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. The following candidate manufacturers are capable of producing equipment and/or products that will satisfy the requirements of this Section. The manufacturer's standard product may require modification to conform to specified requirements:
   1. Baldor
   2. General Electric
   3. Siemens
   4. US Motors
   5. WEG
   6. Approved Equal

2.02 PERFORMANCE/DESIGN CRITERIA

A. Service Conditions:
   1. Temperature: -25-degree C to [+40] [+50] degree C.
   2. Altitude: 0 to 3300 feet above sea level minimum.
   3. Derate motors for higher ambient temperature and for higher altitude with motor size based on brake-horsepower.

B. Design Requirements:
   1. Operation: Continuous.
   2. Compliance: Energy Policy Act of 1992 (EPAct), Final Rule 2014.
   3. Tolerance: +/- 10-percent of rated voltage at rated frequency; +/- 5-percent of rated frequency at rated voltage.
   4. Standard design: NEMA Design B.

C. Service Factor (percent of additional horsepower):
   1. 1.15 for Sine-wave motors.
   2. Dual rating: 1.15 Sine-wave and 1.0 Inverter Duty for Inverter Duty motors.

D. Motor Efficiency:
   1. NEMA Premium™ efficiency electric motor, single-speed, polyphase, 1-500 horsepower, 3600-rpm 2-pole, 1800-rpm 4-pole, and 1200-rpm 6-pole (1-250 HP), squirrel cage induction motors, NEMA Design B, continuous rated. NEMA Standards Publication MG 1 2011, in Table 12-12.

Table 12-12

Full-Load Efficiencies for 60 HZ Premium Efficiency Electric Motors

Rated 600 Volts or Less (Random Wound)

Open Motors								
	2 Pole		4 Pole		6 Pole		8 Pole	
HP	Nominal Efficiency	Minimum Efficiency	Nominal Efficiency	Minimum Efficiency	Nominal Efficiency	Minimum Efficiency	Nominal Efficiency	Minimum Efficiency
1	77.0	74.0	85.5	82.5	82.5	80.0	75.5	72.0
1.5	84	81.5	86.5	84.0	86.5	84.0	77.0	74.0
2	85.5	82.5	86.5	84.0	87.5	85.5	86.5	84.0
3	85.5	82.5	89.5	87.5	88.5	86.5	87.5	85.5
5	86.5	84.0	89.5	87.5	89.5	87.5	88.5	86.5
7.5	88.5	86.5	91.0	89.5	90.2	88.5	89.5	87.5
10	89.5	87.5	91.7	90.2	91.7	90.2	90.2	88.5
15	90.2	88.5	93.0	91.7	91.7	90.2	90.2	88.5
20	91.0	89.5	93.0	91.7	92.4	91.0	91.0	89.5
25	91.7	90.2	93.6	92.4	93.0	91.7	91.0	89.5
30	91.7	90.2	94.1	93.0	93.6	92.4	91.7	90.2
40	92.4	91.0	94.1	93.0	94.1	93.0	91.7	90.2
50	93.0	91.7	91.5	93.6	94.1	93.0	92.4	91.0
60	93.6	92.5	95.0	94.1	94.5	93.6	93.0	91.7

Table 12-12

Full-Load Efficiencies for 60 HZ Premium Efficiency Electric Motors

Rated 600 Volts or Less (Random Wound)

Open Motors

HP	2 Pole		4 Pole		6 Pole		8 Pole	
	Nominal Efficiency	Minimum Efficiency	Nominal Efficiency	Minimum Efficiency	Nominal Efficiency	Minimum Efficiency	Nominal Efficiency	Minimum Efficiency
75	93.6	92.4	95.0	94.1	94.5	93.6	94.1	93.0
100	93.6	92.4	95.4	94.5	95.0	94.1	94.1	93.0
125	94.1	93.0	95.4	94.5	95.0	94.1	94.1	93.0
150	94.1	93.0	95.8	95.0	95.4	94.5	94.1	93.0
200	95.0	94.1	95.8	95.0	95.4	94.5	94.1	93.0
250	95.0	94.1	95.8	95.0	95.8	95.0	95.0	94.1
300	95.4	94.5	95.8	95.0				
350	95.4	94.5	95.8	95.0				
400	95.8	95.0	95.8	95.0				
450	96.2	95.4	96.2	95.4				
500	96.2	95.4	96.2	95.4				

Table 12-12

Full-Load Efficiencies for 60 HZ Premium Efficiency Electric Motors

Rated 600 Volts or Less (Random Wound)

Enclosed Motors

HP	2 Pole		4 Pole		6 Pole		8 Pole	
	Nominal Efficiency	Minimum Efficiency	Nominal Efficiency	Minimum Efficiency	Nominal Efficiency	Minimum Efficiency	Nominal Efficiency	Minimum Efficiency
1	77.0	74.0	85.5	82.5	82.5	80.0	75.5	72.0
1.5	84.0	81.5	86.5	84.0	87.5	85.5	78.5	75.5
2	85.5	82.5	86.5	84.0	88.5	86.5	84.0	81.5
3	86.5	84.0	89.5	87.5	89.5	87.5	85.5	82.5
5	88.5	86.5	89.5	87.5	89.5	87.5	86.5	84.0
7.5	89.5	87.5	91.7	90.2	91.0	89.5	86.5	84.0
10	90.2	88.5	91.7	90.2	91.0	89.5	89.5	87.5
15	91.0	89.5	92.4	91.0	91.7	90.2	89.5	87.5
20	91.0	89.5	93.0	91.7	91.7	90.2	90.2	88.5
25	91.7	90.2	93.6	92.4	93.0	91.7	90.2	88.5
30	91.7	90.2	93.6	92.4	93.0	91.7	91.7	90.2
40	92.5	91.0	94.2	93.0	94.1	93.0	91.7	90.2
50	93.0	91.7	94.5	93.6	94.1	93.0	92.4	91.0
60	93.6	92.5	95.0	94.1	94.5	93.6	92.4	91.0
75	93.6	92.4	95.4	94.5	94.5	93.6	93.6	92.4
100	94.1	93.0	95.4	94.5	95.0	94.1	93.6	92.4
125	95.0	94.1	95.4	94.5	95.0	94.1	94.1	93.0
150	95.0	94.1	95.8	95.0	95.8	95.0	94.1	93.0

Table 12-12

Full-Load Efficiencies for 60 HZ Premium Efficiency Electric Motors

Rated 600 Volts or Less (Random Wound)

Enclosed Motors								
HP	2 Pole		4 Pole		6 Pole		8 Pole	
	Nominal Efficiency	Minimum Efficiency	Nominal Efficiency	Minimum Efficiency	Nominal Efficiency	Minimum Efficiency	Nominal Efficiency	Minimum Efficiency
200	95.4	94.5	96.2	95.4	95.8	95.0	94.5	93.6
250	95.8	95.0	96.2	95.4	95.8	95.0	95.0	94.1
300	95.8	95.0	96.2	95.4				
350	95.8	95.0	96.2	95.4				
400	95.8	95.0	96.2	95.4				
450	95.8	95.0	96.2	95.4				
500	95.8	95.0	96.2	95.4				

2.03 MATERIALS

A. Motor frames:
   1. TEFC motors shall be cast iron.
   2. Aluminum frame motors are not permitted.

B. Stator windings:
   1. Shall be copper with Class F minimum insulation not to exceed Class B temperature rise of 80-degree C at rated load and with Design B torque /current characteristics for all Medium (Integral) motors.
   2. Small (fractional) motors shall be supplied with Class F insulation where available.

C. Rotor material shall be aluminum or copper.

D. Fans shall be non-sparking fan blades.

E. Motor leads shall be non-hygroscopic.

2.04 MOTOR TYPES

A. General Requirements for motors 1/2 horsepower through 500 horsepower:
   1. Three phase, squirrel cage, with copper windings.
   2. Rated for full voltage starting and continuous duty.
   3. Rating shall be:
      a. 460/ 230 volts, three-phase, 60-Hertz, as shown on the contract drawings.
   4. General Purpose Type motors, which may also be called Type 1 per the project equipment specifications shall be:
      a. Open Drip Proof Motors, shall be as defined per NEMA MG1, self-cooled by convection air.

b. Weather-Protected Type I Motors (WP-I), shall be as defined per NEMA MG1, similar to ODP construction with addition of screens to prevent entry of rain, snow, and particles, or objects into the motor. Suitable for clean indoor and protected outdoor installations.

c. Weather Protected Type II Motors (WP-II) shall be as defined per NEMA MG1, with maximum protection from entry of airborne particles, moisture and high velocity air. Suitable for unprotected outdoor installations.

5. Severe Duty Type Motors, which may also be called Type 2 per the project equipment specifications, shall be in accordance with IEEE 841.
   a. Totally Enclosed Fan-Cooled Motors (TEFC) shall be defined per NEMA MG1.
   b. Enclosure: totally enclosed, fan cooled, with external fan blowing air to the motor frame cooling fins for cooling.
   c. Applications: severe duty and most outdoor installations.
6. Explosion Proof Type Motors, which may also be called Type 3 per the project equipment specifications.
   a. Enclosures: UL listed explosion proof
   b. Applications: hazardous locations including Class I and Class II (Division 1 and 2), and Class III classified areas.

B. Motors Less Than 1/2 Horsepower:
1. Type shall be:
   a. Squirrel cage, capacitor start with Class F insulation and copper windings.
   b. Fan motors rated 1/8 horsepower or less: split-phase or shaded-pole type.
2. Rating shall be:
   a. 115Volts, single phase, 60 Hz.
   b. 208 Volts, single phase, 60 Hz.
   c. 230 Volts, single phase, 60 Hz.

2.05 COMPONENTS

A. Inverter-Fed Polyphase Motors per NEMA MG1 Part 31:
1. Applications: variable torque or constant torque loads, for vertical or horizontal motors with variable frequency drive controllers (VFD).
2. Features shall include:
   a. Insulation design to meet 2000-Volt peak at a minimum of 0.1 micro-second rise time.
   b. Built-in motor winding protection as specified.
   c. Electrically insulated bearings or,
   d. Provide Electro Static Technology's AEGIS Shaft Grounding Ring for Bearing Protection or equal. The shaft grounding ring shall be solidly bonded per manufacturer's recommendations.

B. Vertical Motors:
1. Features: Inverter duty or non-inverter duty with solid shaft P-base and high thrust bearing compatible with loads imposed by the driven equipment.

C. Thermal Protection:
   1. Unless specified otherwise in the driven equipment specification, provide the following:
      a. Motors up to 200 horsepower:
         1) Thermal switches (thermostats), one per winding, encapsulated, normally closed and wired in series out to a terminal box).
         2) Motor Nameplate: Marked "OVER TEMP PROT 2" in accordance with NEMA MG 1 12.43.
   2. Motors equal to or greater than 250 horsepower:
      a. 100 ohm platinum RTDs, two per phase embedded in each winding phase and one for each motor bearing.
      b. RTDs shall be brought out to a separate control terminal box mounted on the motor.
      c. Motor Nameplate: Marked "OVER TEMP PROT 1" in accordance with NEMA MG 1 12.43.

D. Motor Nameplates:
   1. Materials: Engraved or stamped stainless steel.
   2. Features shall be as follows:
      a. NEMA Standard MG 1 motor data.
      b. Permanently fastened to the motor frame.
      c. ABMA bearing identification number for motors meeting IEEE 841.
      d. NEMA nominal efficiency for all motors.
      e. NEMA nominal and minimum efficiency for motors meeting IEEE 841.
      f. UL frame temperature limit code for explosion proof motors.
      g. Space heater data.
      h. Over Temperature Protection Type Number.
      i. Temperature device rating and alarm and shutdown setpoint.
      j. Provide motor nameplates for motors with space heaters located in Class I, Division 2, Groups C, and D areas in accordance with NEC 501.125(B).

E. Conduit Boxes:
   1. Provide oversized boxes, with split construction with threaded hubs and petroleum-resistant gaskets.
   2. Conduit boxes can be rotated in order to permit installation in any of four positions 90 degrees apart.
   3. Provide grounding lug located within the conduit box for ground connection.
   4. Provide separate conduit boxes for temperature devices and space heaters.
   5. Separate terminal box for any signal leads (RTD, thermistor, vibration transmitter, etc.).

F. Bearings:
   1. Provide oil or grease lubricated ball bearings, angle contact roller bearings for axial thrust loads, and cylindrical bearings for radial-only loads.
   2. Rated for a minimum L-10 life of 50,000 hours for direct-connected loads.

3. Cartridge type bearings will not be accepted.
4. Fitted with lubricant fill and drain or relief fittings.
5. Belt loads not to exceed forces calculated from NEMA MG 1 Table 14-1 and 14-1A.

G. Bearing lubrication shall be either grease or oil as per the requirements in either 1 or 2:
1. Grease lubricated bearings:
a. Shall be for electric motor use only.
b. Grease shall be capable of higher temperatures associated with electric motors and shall be compatible with Polyurea-based greases.
c. Provide grease fittings, similar to Alemite™ type (or equivalent).
d. Shielded bearings with regreasable provisions are permissible.
2. Provide oil lubricated bearings with externally visible sight glass to view oil level.

H. Lifting Eyes:
1. Provide lifting eyes with a safety factor of 5.
2. Provide one lifting eye for motors more than 50 pounds.
3. Provide two lifting eyes for motors over 150 pounds.

I. Winding Space Heaters when specified or shown:
1. Provide winding space heaters to prevent condensation.
2. Rating: 120 volts, single phase, 60 Hertz.
3. Motor nameplate to show space heater rating in watts and volts.
4. Provide terminal block in motor conduit box for heater leads termination.

2.06 FINISHES

A. Paint Finish:
1. Provide standard manufacturer paint finish.
2. Provide motors with semi-gloss finish, scratch and heat resistance electric motor paint.

PART 3 EXECUTION

3.01 EXAMINATION

A. Delivery Inspection:
1. Inspect driven equipment-motor assembly and components immediately upon delivery and unloading at the job site for damages.
2. Take photos of damage(s) if any, to substantiate the delivery inspection report.

3.02 INSTALLATION

A. Grounding of Motors:
1. Connect the motor feeder ground cable (green) to the grounding lug terminal in the conduit terminal box.

B. Supplemental Grounding of Motors: Provide for motors fed from VFDs, all motors above 100 horsepower, and all motors in classified areas, where feasible.
   1. Bond the motor frame to the grounding grid/electrode system to provide supplemental grounding.

C. Field Coating of Motors:
   1. Refer to the driven equipment specification section and Section 09 90 00 for coating requirements.

3.03 FIELD QUALITY CONTROL

A. Field Testing:
   1. Test each motor in accordance with Section 26 08 00, including the following at minimum:
      a. Measure winding insulation resistance of motors to no less than 10-megohm with a 1000-Vac megohmmeter.
      b. Perform motor phases current imbalance testing for motors 20 horsepower and larger.
      c. Test motors for proper rotation prior to connection to the driven equipment.
      d. Perform thermographic survey per NETA ATS, for motors over 100 horsepower.

B. Field Inspection:
   1. Compare equipment nameplate data with drawings and specifications.
   2. Inspect physical and mechanical condition.
   3. Inspect anchorage, alignment, and grounding.
   4. Verify the installation of breather/drain fittings as specified herein.
   5. Check for proper connections of space heaters, winding and RTDs and or thermostats.
   6. Visually check for correct phase and ground connections:

C. Manufacturer Services: Provide where specified or shown on the drawings.
   1. Provide services to the driven equipment manufacturer for the inspection and certification of the installation of the motor driven equipment.
   2. Provide assistance in the start up and operational testing of the motor driven equipment.

3.04 SYSTEM START UP

A. Commissioning Test: Provide where specified or shown on the drawings.
   1. Provide assistance during the commissioning test of the motor driven equipment.

3.05 CLOSEOUT ACTIVITIES

A. Operation and Maintenance:
   1. Provide the operation and maintenance manual of the motor(s). Include testing result information in the O&M manual.

END OF SECTION

SECTION 43 24 51

PROGRESSING CAVITY PUMPS

PART 1 GENERAL

1.01 SUMMARY

A. This section specifies positive displacement, self-priming, variable-speed progressing cavity type pumps specifically designed for pumping liquid wastewater treatment scum and sludge containing organic solids and small inorganic particles.

1. Pumping unit(s) consist of pump, shafting and couplings, electric motor, and all specified appurtenances, mounted on a common baseplate, and an adjustable frequency drive.
2. Related variable speed drives are not included in this section.

B. Equipment List

Item	Equipment No.
Screw Press Feed Pump 1	72P0301
Screw Press Feed Pump 1 VFD	72VFD0301
Screw Press Feed Pump 1 Motor	72M0301
Screw Press Feed Pump 2	72P0302
Screw Press Feed Pump 2 VFD	72VFD0302
Screw Press Feed Pump 2 Motor	72M0302

1.02 RELATED SECTIONS

A. This section contains specific references to the following related sections. Additional related sections not specifically listed below may apply.

1. Section 01 73 24: Design Requirements For Nonstructural Components And Nonbuilding Structures
2. Section 03 60 00: Grouting
3. Section 09 90 00: Painting and Coating
4. Section 26 29 23: Variable Frequency Motor Controllers
5. Section 26 24 19: Motor Control Centers
6. Section 43 05 11: General Requirements for Equipment
7. Section 43 05 13: Rigid Equipment Mounts
8. Section 43 05 14: Machine Alignment
9. Section 43 05 17: Vibration and Critical Speed Limitations
10. Section 43 05 21: Common Motor Requirements for Equipment
11. Section 40 61 96: Process Control Descriptions

1.03 REFERENCES

A. This section contains references to the following documents. These references are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. If requirements of this section conflict with those of the listed documents, requirements of this section prevail.

B. Unless otherwise specified, reference documents refer to documents in effect at the time of Advertisement for Bids or Invitation to Bid (or on the effective date of the Agreement if no Bids). If referenced documents have been discontinued by the issuing organization, refer to replacement documents issued or otherwise identified by that organization. If there are no replacement documents, refer to the last version of the document before it was discontinued. Where document dates are given in the following listing, those documents refer to the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, discontinued, or replaced.

Reference	Title
ABMA 9	Load Ratings and Fatigue Life for Ball Bearings
AGMA 6013-A	Standard for Industrial Enclosed Gear Drives
ASTM A108	Standard Specification for Steel Bar, Carbon and Alloy, Cold-Finished
ASTM A322	Standard Specification for Steel Bars, Alloy, Standard Grades
ANSI/HI 3.1 – 3.5	Rotary Pumps
ANSI/HI 3.6	Rotary Pump Tests

1.04 DEFINITIONS

A. Terminology used in this section conforms to the following definitions:
   1. Equipment pad: concrete foundation (block or slab) supporting and elevating equipment mounts above the supporting structural floor slab or local grade.
   2. Mounting pads: thickened or raised areas of baseplates where feet or mounting surfaces of mounted equipment and drivers rest on the baseplate or soleplate.
   3. Baseplate: fabricated (welded structural steel elements), cast, or plate steel base, with or without grout fill, as specified, providing a common mounting element on which the legs, feet, or mounting surfaces of equipment (pump, gearbox, and motor) are mounted by bolted connections.
   4. Pump drive configuration types:
      a. “B” or close coupled “block”: close coupled pump configuration employing a direct coupled motor and gear reducer or gear motor such that the motor/reducer combination provides the pump’s shaft bearing support.
   5. “Universal joint”: rigid connecting rod with lubricated joints at each end connecting the pump drive shaft to the rotor (excludes flexible connecting shaft drives).

1.05 ADMINISTRATIVE REQUIREMENTS

A. Coordination
   1. See Section 01 12 16: Work Sequence.

2. Coordinate pump and motor operational and starting characteristics with variable frequency drive settings used for control of this equipment. Incorporate the following final variable frequency drive (VFD) settings into the operation and maintenance submittal under paragraph 1.06.C – Closeout Submittals:
    a. Motor minimum operational speed
    b. Motor maximum operational speed
    c. Torque characteristics
    d. Motor ramp up and ramp down speed, voltage, and hertz requirements
    e. Other operating limits imposed by the driven equipment for operation and warranty.

B. Unit Responsibility
1. Assign unit responsibility, as specified in Section 43 05 11, to the pump manufacturer for the equipment specified in this section, and electric motors specified in Section 43 05 21, and variable frequency motor controllers specified in Section 26 29 23.
2. Provide a completed and signed Unit Responsibility Certification Form (Form 43 05 11-C, Section 01 99 90).

1.06 SUBMITTALS

A. Action Submittals
1. Comply with procedures described in Section 01 33 00.
2. Submit a completed Certificate of Unit Responsibility attesting that the Contractor has assigned and the pump manufacturer accepts unit responsibility in accordance with the requirements of this section and Section 43 05 11-1.02: Unit Responsibility. No other submittal material will be reviewed until the certificate has been received and found to be in conformance with these requirements.
3. Submit a copy of this specification section and those listed below, with addendum updates included, with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements.
    a. This section (43 24 51)
    b. Section 43 05 11: General Requirements for Equipment
    c. Section 43 05 13: Rigid Equipment Mounts
    d. Section 43 05 21: Common Motor Requirements for Equipment
    e. Section 26 29 23: Variable Frequency Motor Controllers
    f. Section 26 24 19: Motor Control Centers
4. Use check-marks (✓) to denote full compliance with a paragraph as a whole. Underline and denote deviations with a number in the margin to the right of the identified paragraph. Remaining portions of the paragraph not underlined signify the Contractor's compliance with the specifications. Submit a detailed, written justification for each requested deviation. Failure to submit a copy of the marked-up specification sections, along with justification(s) for all requested deviations from the specification requirements, with the submittal, shall be sufficient cause for rejection of the entire submittal with no further consideration.

5. Provide a copy of the contract document control diagrams and process and instrumentation diagrams relating to the submitted equipment. Include addendum updates applying to the equipment in this section, marked to show specific changes necessary for the equipment proposed in the submittal. If no changes are required, mark the drawing or drawings with "no changes required". Failure to include copies of relevant drawings with the submittal shall be cause for rejection of the entire submittal with no further review.
6. Provide drawings showing general dimensions and confirming the size of pumps, motors, drives, and specified appurtenances; variable frequency drives (VFD); piping connections; construction details of equipment (including bearings); wiring diagrams; and weight of equipment.
7. Provide predicted performance curves developed for the specific application. Show speed, capacity, head, horsepower, efficiency, and net positive suction head (NPSH) required for the specified operating range.
8. Provide motor submittal information specified in Section 43 05 21 and conforming to paragraph 2.08: Motor and Drive Unit.
9. Submit detail drawings of the pump and driver unit foundation demonstrating conformance to this section and Section 43 05 13. Include drawings depicting type, size, number, projection, and arrangement of anchor bolts, dimensional drawings of the baseplates, and dimensional drawings for the concrete support pad for the equipment. Drawings shall also depict all other pertinent information, including: location of equipment pads and reinforcement; equipment drains; elevation of top of grout and grout thickness; elevation of top of baseplate or mounting block; size and location of electrical conduits; and any other equipment mounting features embedded in equipment pad.
10. Comply with submittal requirements of Section 26 29 23:
    a. Show pump antireversal holdback or motor brake as specified in paragraphs 2.06.F, Antireversal Holdback and 2.06.G, Motor Brake.
    b. Show pump stator temperature devices as specified in paragraph 2.10, Electrical and Instrumentation.

B. Informational Submittals
1. Comply with procedures described in Section 01 33 00.
2. Provide performance guarantee as specified in paragraph 1.07: Quality Assurance.
3. Provide a letter of confirmation of suitability of variable frequency drives being provided by the Contractor for this equipment in accordance with Section 26 29 23.
4. Provide operation and maintenance information as specified in Section 01 78 23.
5. Identify coordination items required for proper setup of the variable frequency drives as specified in paragraph 1.05.A: Coordination.
6. Provide motor product data as specified in Section 43 05 21.
7. Provide documentation from the pump manufacturer attesting to the limitations on loads and moment forces that can be tolerated on the pump connection nozzles and recommended connection details to be used.
8. Provide the pump manufacturer’s certified data showing location of critical speeds in relation to operating speeds in accordance with Section 43 05 17.
9. Provide certification of satisfactory factory testing of each unit as specified in paragraph 1.07: Quality Assurance. Include copies of test logs and resulting performance curves.

10. Provide documentation of radial and thrust loads at the rated operating condition. Provide explanation of where thrust loading is accommodated in the specified drive configuration; and corresponding ABMA L-10 bearing life calculations for pump, gearbox, and motor bearings as specified in paragraphs 2.06.E: Shaft Seals and Bearings and 2.08: Motor and Drive Unit.
11. Provide mill certifications confirming hardness of rotor and stator as specified in paragraph 2.05.
12. Provide documentation of field alignment data in accordance with Section 43 05 14.
13. Provide operating and maintenance information as specified in Section 01 78 23, including manufacturer's warranties specified in paragraph 1.02 Warranty and Section 01 78 23 and record of final VFD configuration settings.
14. Provide certification and supporting data that the pump manufacturer has inspected the pumps under operating conditions and found them in compliance with the vibration and critical speed limitations specified in Section 43 05 17.
15. Submit Installation Certification Form 43 05 11-A as specified in paragraph 3.04.
16. Submit Training Certification Form 43 05 11-B as specified in paragraph 3.04.

C. Closeout Submittals
   1. Comply with procedures described in Section 01 33 00.
   2. Provide warranties as specified in paragraph 1.09.
   3. Provide record of final VFD configuration settings as specified in paragraph 1.05.A. Coordination.
   4. Spare parts
      a. Tag and store as specified in Section 43 05 11.
      b. Provide the following spare parts if pumps are furnished with packing seals:
         1) One set of packing tools to service the pumps
         2) For each pump model and size:
            a) Two sets of packing rings
            b) One brass lantern ring
      c. Provide the following spare parts for each pump model and size:
         1) One stator assembly with thermistor sensor sleeve, if provided
         2) One rotor
         3) One connecting rod with bushings and/or flexible shaft
         4) One set connecting rod joint assembly parts
         5) One set universal joint parts (gear, 'Z', or pin), including joint seals
         6) For pumps with packing seals, one shaft sleeve or one extension shaft through stuffing box if sleeves are not available
         7) For pumps with mechanical seals, one spare mechanical seal
         8) One complete gasket set including O-rings
         9) One pump bearing kit, where applicable
         10) One thermistor controller
         11) One special disassembly tool, including packing extractors, tampers, and ear reducer dip sticks
         12) One motor coupling or set of spare belts, if applicable

1.07 QUALITY ASSURANCE

A. Factory Testing
   1. Shall be performed according to the manufacturer's standard test procedures.
   2. Provide certified test results as an Informational Submittal.

B. Performance Guarantee
   1. Manufacturer must guarantee the pump performance specified in paragraph 2.03 Performance/Design Criteria. The guarantee shall be in writing, signed by an officer of the manufacturing corporation, and notarized. Under no circumstances shall deviations from the specified operating conditions result in overload of the driver furnished with the equipment, nor shall such deviations result in power requirements greater than the driver's nameplate (1.0 service factor) rating.

1.08 DELIVERY, STORAGE, AND HANDLING

A. Comply with procedures described in Section 01 66 00.

1.09 WARRANTIES

A. Universal Joints five-year Full Warranty
   1. Provide all warranties as described in the General Conditions, including normal commercial warranties available from equipment manufacturers.
   2. The rotor drive trains, consisting of universal joints, connecting rods, and related components, furnished with progressive cavity pumps specified in this section, shall be warranted by the pump manufacturer against defects in materials, workmanship, and wear regardless of the cause or fault of the wear or failure for a period of five years.
   3. Rotor drive trains shall be repaired or replaced by the pump manufacturer at no cost to the Owner during the five-year warranty period.
   4. The pump manufacturer shall provide the warranty labor for repair or replacement of rotor drive trains.
   5. The warranty period shall commence at the date of final acceptance of the equipment specified in this section.

B. Universal Joints Subsequent five-year PARTS Warranty
   1. Rotor drive trains, consisting of universal joints, connecting rods, and related components, furnished with progressive cavity pumps specified in this section, shall be warranted by the pump manufacturer against defects in materials, workmanship, and wear regardless of the cause or fault of the wear or failure for a subsequent period of five years.
   2. Replacement parts and related components of rotor drive trains shall be repaired or replaced by the pump manufacturer at no cost to the Owner during the subsequent five-year warranty period.
   3. The warranty period for the subsequent five-year warranty shall commence at conclusion of the first five-year warranty period.

C. Rotors and Stators Warranty

1. The rotors and stators, furnished with progressive cavity pumps specified in this section, shall be warranted by the pump manufacturer against defects in materials, workmanship, and wear regardless of the cause or fault of the wear or failure for a period of 10,000 hours of operation or two years, whichever occurs first.
2. Rotors and stators shall be repaired or replaced by the pump manufacturer at no cost to the Owner during the warranty period.
3. The pump manufacturer shall provide the warranty labor for repair or replacement of rotors and stators.
4. The warranty period shall commence at the date of final acceptance of the equipment specified in this section.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. The following candidate manufacturers are capable of producing equipment and/or products satisfying the requirements of this section. The manufacturer's standard product may require modification to conform to specified requirements.

B. Candidate Manufacturers

1. Moyno 2000
2. Seepex Range BN
3. Approved equal

2.02 TYPE

A. Pumps are self-priming, positive displacement, progressing cavity type.

B. Pumps, electric motor, and all specified appurtenances shall be mounted on a common baseplate.

C. Pumps shall be designed and selected for continuous duty pumping of concentrated solids derived from the treatment of wastewater. All pumps shall be suitable for exposure to scum consisting of floatable materials skimmed from the surface of primary sedimentation tanks; and primary and thickened sludge containing grit, small particles of wood, rags and stringy material, industrial solvents, heavy greases, fats, detergents, petroleum products, and organic particles in concentrations as great as 10 percent. Primary sludge and thickened sludge that includes primary sludge shall be considered moderately abrasive.

2.03 PERFORMANCE/DESIGN CRITERIA

A. Service Conditions

Service Condition	Value
Equipment number	72P0301 72P0301
Area exposure	Per Section 01 61 45
Fluid type	anerobically digested solids
Solids concentration,	1.7% - 2.8%
Fluid temperature range	40 to 75 degrees F
pH range	5.5 to 6.5
Control	Speed based on level in Day Tank

B. Operating Conditions

Operating condition	Value
Equipment number	72P0301 72P0301
Rated capacity, gpm	105
Rated head, psig [a]	20
Inlet pressure range, psig [b]	2.0 – 3.0
Maximum speed, rpm [c]	175
Minimum, rpm [d]	75

NOTES:

(a) Rated head (discharge pressure) is based on pumping clean water at 68 degrees F.

(b) Potential range in pressure at the pump inlet (suction). The pump shall be capable of continuous operation over the entire inlet pressure range.

(c) Pump speed after fixed reduction and at the highest allowed VFD frequency.

(d) Pump speed after fixed reduction and at the lowest allowed VFD frequency for minimum flow and motor cooling.

C. Design Requirements

Design requirement	Value
Equipment number	72P0301 72P0301
Pump	
Suction and disch port size, in.[a]	6
Maximum pump layout dimensions, in. (LxWxH) [b]	108x14x20
Minimum number of pump stages	2
Shaft seal type [c]	Double Mechanical
Pump drive configuration [d]	Type B
Rotor drive connection [e]	Universal Joint
Antireversal holdback	Yes
Run dry protection	Yes
Motor (See Section 43 05 21)	
Horsepower	20

Design requirement	Value
Equipment number	72P0301 72P0301
Type (See Section 43 05 21)	Constant Torque Project defined – Wet or Corrosive Severe, TEFC
Inverter duty	Yes
Space heater	No
Thermal protection	Yes
Motor brake	Yes
Ambient duty rating (ºC)	+50
Operating speed, rpm, maximum	1800
Voltage rating	460 volt, 3 Phase
Hazardous rating	Unclassified
Reversing motor	No
Multispeed motor	Yes
Motor starting type	Adjustable Frequency Drive
Temperature Sensors	Manufacturer's standard pump stator temperature sensor and temperature protection relay. This temperature sensor shall be provided in addition to the thermistors provided in the motor windings.

Note:

a. If a suction or discharge port size different than the size specified is provided, pipe reducers required to conform the pump installation to the designed piping shall be provided at no additional cost to Owner.

b. Maximum pump layout dimension is the largest footprint allowable for the entire pump assembly, including the motor. The pump shall not exceed any one dimension listed.

c. See paragraph 2.06.E: Shaft Seals and Bearings.

d. See paragraphs 1.04: Definitions and 2.06.B: Pump Drive Configuration.

e. See paragraphs 1.04: Definitions and 2.06.C: Rotor Drive Connection.

2.04 SYSTEM OPERATION

A. Both pumps are duty pumps dedicated to a screw press. Pumps will be controlled by the central plant control system. Pumps will be started and stopped and pump speed adjusted in response to changing day tank level, and corresponding liquid depth in the sludge wet well to match pumping rate with the rate of inflow to the day tank.

2.05 MATERIALS

A. Materials of construction shall be as follows:

Component	Material
Rotor	ASTM A322 Grade 4150 cold finish alloy steel stock per ASTM A108 with hard chrome plating, 0.010-inch minimum thickness, 800 Vickers minimum hardness
Stator	Buna-N synthetic rubber with a Shore durometer hardness between 50 and 70, and bonded to a steel tube
Pump body	Cast iron
Shafts or shaft sleeves	416 Chrome steel with 0.010-inch minimum thickness hard chrome plating, 800 Vickers minimum hardness

B. Materials specified are considered the minimum acceptable for the purposes of durability, strength, and resistance to erosion and corrosion. The Contractor may propose alternative materials to provide greater strength or meet required stress limitations. However, alternative materials must provide at least the same qualities as those specified for the purpose.

2.06 COMPONENTS

A. Rotor and Stator
   1. Rotor and stator shall be a minimum two-stage design, however the number of stages required shall be not less than the number specified in paragraph 2.03.C: Design Requirements.
   2. Similarly matched convolutions shall form a cavity between the rotor and stator, which shall progress from the pump's inlet to discharge port with the operation of the rotor.
   3. The fit between the rotor and stator at the point of contact shall compress the stator material sufficiently to form a good seal and prevent leakage from the discharge back to the inlet end of the pumping chamber.
   4. The stator material hardness shall be suitable for the abrasiveness of the medium to be pumped. Where softer stators (i.e., 50 to 54 shore durometer) are provided, the rotors shall be oversized to assure maintenance of a good seal to minimize stator wear.

B. Pump Drive Configuration
   1. Pump drive configurations shall be as follows (see definitions in paragraph 1.04: Definitions).
      a. Pump Configuration B or close coupled “block” pump configuration shall employ direct coupled motor and gear reducer or gear motor such that the motor/reducer combination provides the pump’s shaft bearing support.
      b. Pump configurations BA-D and BA-V shall provide for a separate bearing frame mounted between the gear reducer and pump that provides for pump’s shaft bearing support.
      c. Pump Configuration BA-V or “bearing assembly–V-belt” shall include a V-belt drive. Provide side-by-side orientation where shown on the drawings. Provide gearing such that sheave turndown is approximately 1.25 to 1. Pump manufacturer shall also provide a pump base sufficiently large for a gear drive sheave of sufficient size and rating such that the assembly is capable of a pump sheave replacement resulting in approximately 125 rpm pump speed.

C. Rotor Drive Connection
   1. The connections between the drive and rotor shall be universal joints, which include gear joints, or Netzsch NEMO® ‘Z’ joints, or pin joints] conforming to the following requirements:
      a. Gear Joints
         1) Gear joints shall be precision machined grease lubricated crowned gear type joints.
         2) Gear joints shall be rigid spline design machined from ASTM 331 alloy steel, Grade A8620.

3) The balls and sockets shall be machined from chrome alloy tool steel and shall be designed to withstand shock and thrust reversal.
4) Gear joints shall be protected against the entrance of dirt, sludge, and other foreign objects by a wire reinforced elastomeric seal.
5) Gear joints shall be positively secured to the connecting rod to ensure against failure. The connecting rod shall be manufactured of alloy steel.

b. Netzsch NEMO® 'Z' Joints
1) Joints shall be cartridge design cross journal pivot type joints connected by a connecting rod.
2) The pivot joints shall be manufactured of alloy steel SAE 8140.
3) The connecting rod shall be manufactured of alloy steel SAE 8140.
4) Axial forces and torques shall be transmitted by the bearings of the pivots.
5) The connecting rods shall not be subject to mechanical wear from joint flexing. Joints shall be oil lubricated. Joints shall be protected against the entrance of dirt, sludge, and other foreign objects by a double sealing system that includes Viton elastomeric sleeves to prevent abrasion from the product.

c. Pin Joints
1) Pin joints shall be positively sealed and lubricated.
2) Pin joints shall have replaceable bushings, constructed of air-hardened tool steel of 57-60 HRc, in the rotor head and connecting rod.
3) Pins shall be constructed of high-strength steel, air hardened to 60-65 HRc.
4) Pin joints shall be grease lubricated with a high temperature (450 degrees F), PTFE filled synthetic grease, covered with a Buna N or Hypalon sleeve, and positively sealed with hose clamps constructed of 304 stainless steel.
5) Pin joint sleeves shall be fastened on each end with a metal holding band.
6) A 316 stainless steel shell shall cover the pin joint assembly to protect the elastomer sleeve from being damaged by tramp metals and glass.
7) Pin joints shall be rebuildable in the field by replacing bushings and pins.

D. Casing
1. The pump casing shall be provided with a cleanout opening on each side of the inlet fitting.
2. Cleanout opening shall be located immediately opposite the rotor head drive joint to provide access for maintenance.
3. A minimum class 125 compatible flanged connection shall be provided at both the inlet and discharge ports.
4. The pump suction shall be provided with a 1/2-inch tap to permit installation of a pressure instrument and a water lubrication system.
5. Pump casings shall be supplied with suitable threaded connections to allow for priming and draining.

E. Shaft Seals and Bearings
1. Each pump shall be provided with oil or grease lubricated thrust and radial bearings designed for all loads imposed by the specified service.
2. Bearing life for all pumps, gear box, and motor bearings, calculated to the ABMA L-10 standard, shall be 100,000 hours minimum.

3. Bearing life calculations shall be submitted as an Informational Submittal.
4. Each pump shall be fitted with a shaft seal of the type specified in paragraph 2.03.C: Design Requirements. Seals shall be Chesterton 255 mechanical type

F. Antireversal Holdback
1. Where listed in paragraph 2.03 C: Design Requirements, each pump shall be equipped with a differential friction-type holdback designed to prevent reversal of flow when the pump is not in operation. Unless otherwise specified, the holdback shall act directly on the pump shaft and be equipped with a housing to protect the unit against the entrance of dust, dirt, and moisture. Anti-reversal holdbacks shall be adequately sized for the specified service. Shaft extensions shall be provided where required.
2. Where a gear reducer is direct connected, the holdback shall be incorporated into the gearbox.

G. Motor Brake
1. In lieu of friction type holdbacks, and at no additional cost to the Owner, each pump may be equipped with a C-face mounted electric motor brake for holding the motor shaft from turning when the motor is not running. Brake shall release when motor starts and engage when motor shuts down or on power failure. The brake shall provide a minimum 50 pounds per feet of braking force. The brake shall be integrated with the motor and pump, as a complete package with all necessary mounting components. The brake shall be spring set and electrically released. The brake shall be as manufactured by Stearns or approved equal. The following features shall be included:
   a. NEMA 4X enclosure
   b. 480 Vac 1 phase rated solenoid, including optional terminal strip
   c. Manual release knob with automatic reset
   d. 120V rated double pull double throw (DPDT) dry contact output for detection of the brake position. Contact shall be closed when brake is in the open position and open when brake is set.
2. The Contractor shall be responsible for preparing and obtaining approval from the Construction Manager of submittals showing all revisions necessary to implement this change in design.

2.07 EQUIPMENT MOUNTS

A. Mounting Plates
1. Each pump along with its associated motor, drive, and appurtenances shall be rigidly mounted on a baseplateas defined in Section 43 05 13.
2. Each baseplate shall contain and direct excess seal water to a single outlet.
3. Pump and drive assemblies shall be supported on a common concrete equipment pad, as specified.
4. Mounting plate shall be leveled to 0.005inch/foot or less.

B. Grout Type
1. Use epoxy grout or cementitious non-shrink grout per Section 03 60 00.

C. Equipment Anchors
   1. Install per Standard Detail D01004

D. Equipment Anchor Sleeves
   1. Install per Section 43 05 13.
   2. Length shall not be less than [6D] (D = nominal bolt diameter; bolt diameter determined by mounting plate manufacturer).

E. Equipment Pad
   1. Install per Standard Detail D01007

2.08 MOTOR AND DRIVE UNIT

A. Electric motors shall conform to the requirements of paragraph 2.03.C, Design Requirements and Section 43 05 21. Motors shall include 120 Vac space heaters. Motors for adjustable speed pumps shall be inverter duty, and include a high motor temperature switch.

B. The drives shall be designed to transmit 150 percent of the maximum torque required to be transmitted under the full range of operating conditions and other requirements specified in paragraph 2.03.C, Operating Conditions. Belts, sheaves, and guards shall be in accordance with Section 43 05 11. Unless otherwise specified, pumps shall be motor driven by a V-belt drive. The maximum speed reduction ratio for the V-belt shall be 4:1.

C. Gear motors and gear reducers, designed in accordance with AGMA 6013-A (Service Factor 1.50), shall be provided. The reduction ratio shall be that required to operate the pump at its maximum operating speed when the motor is operating at its nominal rated full speed.

D. Motors and drives shall be mounted as specified in this section and as shown. Alternative configurations will not be considered.

E. Bearing life calculations shall be submitted for the gear box and motor as specified in paragraph 2.06.E: Shaft Seals and Bearings.

2.09 ADJUSTABLE SPEED DRIVES

A. Pumps that require VFDs are listed within this section. VFDs shall be constant torque type and as specified in Section 26 29 23. For VFD driven units, the pump supplier shall be responsible for providing the fixed reduction between the motor and the pump. The reduction ratio shall be that required to operate the pump at its maximum operating speed when the motor is operating at its nominal rated full speed in accordance with the schedule in paragraph 2.03.B, Operating Conditions. VFD controls shall be such that pumps cannot operate at a speed lower than that which corresponds to the minimum pumping rate as specified within this Section.

2.10 ELECTRICAL AND INSTRUMENTATION COMPONENTS

A. Run-dry protection shall be provided by stator temperature monitoring.

B. Stator Temperature Monitoring
   1. The pump stator shall be fitted with a sensor sleeve and thermistor sensor, with the thermistor controller installed by the Contractor near the pump.
   2. Controller shall monitor the stator temperature and activate a shutdown and alarm sequence to the motor starter if the stator temperature reaches the adjustable limit on the controller.
   3. The controller shall include a manual local and remote reset function.
   4. The controller shall be 115 VAC/60 Hz powered. Controller enclosure shall be NEMA 4X
   5. The thermistor sensor shall be capable of functioning in the presence of water and other abrasive, highly viscous, sticky materials.

C. Suction pressure monitoring
   1. specify low pressure switch components and action.
   2. Upon achieving a specified head under liquid falling conditions, the low pressure switch will cause the plant control system to initiate a shutdown.

2.11 CONTROLS

A. See Section 40 61 96 for pumping equipment and system control strategies.

2.12 FINISHES

A. Comply with procedures described in Section 09 90 00.

2.13 SOURCE QUALITY CONTROL

A. Hydrostatic Tests
   1. Factory test all pressure sustaining parts.
   2. Conform to the requirements of paragraph 8.3.2 of ANSI/ ANSI/API 610.
   3. Hold castings at the test pressure for 30 minutes for all pumps with discharge nozzles 14 inches in diameter and less, and 60 minutes for pumps with discharge nozzles 16 inches in diameter and greater.
   4. Certify correct and notarize by an officer of the pump manufacturer's corporation.

PART 3 EXECUTION

3.01 EQUIPMENT MOUNTING

A. Comply with procedures described in Section 43 05 13.

B. Position equipment pad and anchors for final placement of equipment.

C. Use a bolting template to position equipment anchors.

D. Pour and cure equipment pad.

E. Prepare equipment pad surface for bond with grout bed under baseplate.

F. Level baseplate.

G. Pour grout bed supporting baseplate; eliminate grout voids below baseplate as applicable.

H. Cure.

I. Tension equipment anchors.

J. Provide completed Form 43 05 13-A, Section 01 99 90, for each equipment installation.

3.02 ALIGNMENT

A. Comply with procedures described in Section 43 05 14.

3.03 FIELD QUALITY CONTROL

A. Field Testing
   1. Test equipment and systems as specified in Section 01 45 23, including:
      a. Performance Tests: All Note that the functional tests specified in Section 01 45 23 shall include measurement of pump performance at the maximum nominal pump speed and specified pump pressure.
      b. Operational Tests
         1) Testing period shall not be not less than 48 hours.
         2) Coordinate operational testing with the demonstration and training requirements specified in Section 01 79 00.
   2. Include in the bid all costs for services of Testing Firms and Design Professionals performing these services.

B. Manufacturer Services
   1. On-Site Inspections and Training
      a. Provide a factory-trained manufacturer's representative at the Site for the following activities. Specified durations do not include travel time to or from Site.
         1) Installation inspections
            a) Assist, supervise, and inspect the Contractor's activities during installation.
            b) Provide 8 inspection hours.
            c) Provide a completed Form 43 05 11-A, Section 01 99 90.
         2) Component test phase inspections
            a) Assist, supervise, and inspect the Contractor's activities during the component test phase specified in Section 01 45 23 and this section.
            b) Provide 8 inspection hours.
         3) System test phase inspections
            a) Assist, supervise, and inspect the Contractor's activities during the system test phase specified in Section 01 45 23.
            b) Provide 8 inspection hours.

4) Operational test phase inspections
   a) Assist, supervise, and inspect the Contractor's activities during the operational test phase specified in Section 01 45 23.
   b) Provide 8 inspection hours.
5) Training Sessions
   a) Comply with procedures described in Section 01 79 00.
   b) Provide a minimum of 8hours classroom training for each training session.
   c) Conduct two training sessions, 0ne training session per week on two consecutive weeks to accommodate the shift schedules of operation and maintenance staff.
   d) Certify completion of training on Form 43 05 11-B, Section 01 99 90.

3.04 SYSTEMS START UP

A. Comply with procedures described in Section 01 45 23.

B. Preoperational (factory) testing
   1. See paragraphs 1.07 and 2.13.

C. Component testing
   1. Under operating conditions, verify that the pumps comply with vibration and critical speed limitations specified in Section 43 05 17. Submit certification and supporting data demonstrating compliance.

D. Commissioning
   1. See section 01 91 00.
   2. Minimum period of successful operation, as part of a system, shall be 1 week on specified process fluid.

END OF SECTION

SECTION 46 71 01

TEMPORARY SLUDGE DEWATERING FACILITIES

PART 1 GENERAL

1.01 SUMMARY

A. Scope of Section

1. This section specifies sludge dewatering to be installed at the Salmon Creek Wastewater Treatment Plant (SCTP) on a temporary basis during the contract (temporary facilities). The purpose of the temporary facilities is two-fold: (1) to allow the Contractor to work in the Solids Processing Center without being impeded by operating equipment; and (2) to provide the Owner with reliable sludge dewatering during the period while the Contractor is modifying the Solids Processing Center.
2. The temporary dewatering facilities shall consist of one of the pre-selected FKC screw press and an inclined shaftless screw conveyor procured by the contractor, and installed in the Biosolids Storage area. Contractor shall install the screw press and conveyor system and any ancillary equipment including piping, electrical requirements, access platforms, and panels..
3. Temporary dewatering facilities will be operated by Owner staff. Contractor shall be responsible for maintenance of the temporary facilities.

B. Equipment numbers associated with items specified in this section are listed in the table below.

1. FKC Screw Presses

Item	Equipment No.
Temporary Inclined Conveyor	78M4499
Screw Press 2 Control Panel	72LCP2701
Screw Press 2 Floc Tank	72T262710
Screw Press 2 Floc Tank Mixer	72MIX2710
Screw Press 2	72SCP2720

C. The temporary dewatering facility shall include all components necessary for a completely functioning dewatering facility, including but not limited to:

1. Dewatering equipment:
   a. Polymer mixing/blending/injection system (polymer will be provided by the Owner)
   b. Piping as needed to convey blended sludge to the dewatering equipment
   c. Screw conveyor to discharge dewatered solids to adjacent biosolids bay.
   d. Wash water system connected as needed to the closest local plant water supply:
   e. Drainage and capture system for filtrate and spent wash water from the dewatering equipment to the process drains indicated on Figure 2.
   f. Remote local control panel with HMI connected located near the temporary installation location and connected to the main local control panel that houses all system controls.
   g. Electrical service for each skid control panel shall be derived from a breaker in existing Solids Processing Center electrical room;

h. All electrical distribution as required

2. Controls:
   a. Weather protection enclosures for exterior units, as needed
   b. Ventilation for the enclosures

D. Refer to Sheet 78-MT-101 for a conceptual temporary dewatering facility layout within the Biosolids Storage Bay. Refer to Figure 4 at the end of this Section for a process flow diagram of the temporary facility.
   1. The temporary dewatering facility shall be located within the Biosolids Storage area adjacent to the Solids Processing Center
   2. The electrical service shall be installed from the Solids Processing Center electrical room for both facility location options.

E. Required Coordination:
   1. Contractor shall review and coordinate the layout of the proposed temporary dewatering screw press with the Owner and Engineer.
   2. Contractor shall propose layouts of walkways, final location of equipment, piping and conveyor supports, and access stairs.
   3. Contractor shall coordinate with the manufacturer regarding installation, start-up of the screw press, and disassembly of the screw press for re-installation inside the Solids Processing Center.

1.02 RELATED SECTIONS

A. This Section contains specific references to the following related sections. Additional related Sections may apply that are not specifically listed below.

1.03 SUBMITTALS

A. The following shall be submitted in accordance with Section 01 33 00 - Submittal Procedures:
   1. A copy of this specification section, and those listed below with addendum updates included, with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements.
      a. Checkmarks (✓) shall denote full compliance with a paragraph as a whole. Deviations shall be underlined and denoted by a number in the margin to the right of the identified paragraph. The remaining portions of the paragraph not underlined will signify compliance on the part of the Contractor with the specifications. Include a detailed, written justification for each deviation. Failure to include a copy of the marked-up specification sections, along with justification(s) for any requested deviations to the specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration.
   2. Contractor shall submit an electrical plan including the connection details and locations of temporary electrical conduit and wiring from the Filter Building electrical room to the temporary dewatering units. The electrical plan shall be submitted to the Engineer for approval.

3. Layout plan showing location of temporary dewatering equipment, piping, pumps, control panels and ancillaries. Site plan(s) shall be annotated to indicate location of connection points to all existing utilities, drainage and process piping, and electrical power service. Space to be left clear for required maintenance of temporary facilities shall be indicated on the site plan. Layout plan shall be drawn at a scale of 1/8 inch equal to 1 foot, or larger.
4. Drawings, cutsheets, brochures and photographs of the proposed temporary dewatering facility, including but not limited to, piping materials, valves, and fittings.
5. Statement confirming that the proposed equipment will comply with the design criteria specified herein.
6. Operations manual for the temporary dewatering facility, describing the normal mode of operation, as well as emergency and troubleshooting procedures.

1.04 QUALITY ASSURANCE

A. Unit Responsibility:
   1. Assign unit responsibility, as specified in Section 43 05 11 - General Requirements for Equipment, to the supplier of the temporary facilities specified in this Section.

B. Qualifications
   1. Suppliers of temporary dewatering facility shall have a minimum of 5 years of providing temporary dewatering services.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Fukoku Kogyo Company (FKC), as stated in Sections 46 76 27 and 41 12 13.16 was pre-selected by the Owner for supplying the screw press and screw conveyor.

B. Ancillary equipment including piping, electrical requirements, access platforms, and panels shall be supplied by the Contractor based on the Section that specifies the respective equipment.

2.02 CONDITIONS/PERFORMANCE/DESIGN CRITERIA

A. Equipment furnished under this Section shall be suitable for operation in the conditions described, provide the performance required and with the design criteria specified.

B. Environmental Conditions
   1. Equipment in this Section shall be subjected to environmental conditions in accordance with Section 01 11 80 – Environmental Conditions.
   2. The equipment specified in this Section will be located outdoors, where ambient temperatures will range from 20-degrees Fahrenheit in the winter and 100-degrees Fahrenheit in the summer.
   3. All outdoor temporary piping shall be insulated.

C. Service Conditions

1. Refer to Section 01 61 45 – Area Exposure Designations for site-wide area exposure designations and environmental conditions.

D. Operating Conditions

1. Reference Section 01 12 16 - Maintenance of Plant Operations and Construction Sequencing for a description of work sequence constraints.
2. Feed Sludge:
    a. During the operation of the temporary dewatering facility, primary sludge and waste activate municipal sludge is blended and anaerobically digested to meet class B solids regulations. The anaerobically digested sludge is pumped from a biosolids day tank to the temporary facility and will be dewatered by the systems specified herein.
    b. The temporary dewatering facility will be capable of operating 24-hours a day.
    c. The existing belt filter press feed pumps will be used to pump sludge from the day tank to the temporary dewatering facilities. Temporary piping shall be installed to convey digested sludge to the temporary units. Piping connections and routing shall be provided by the Contractor. Piping connects and routing shall be approved by the Owner and Engineer.
    d. Digested sludge to be dewatered will be conditioned using polymer, polymer mixing equipment and a polymer-sludge mixing system. Polymer solution will be provided by the Owner. Contractor shall supply and install piping from the existing polymer feed pumps to the temporary dewatering system. Screw press manufacturer shall supply the polymer injection ring that Contractor shall install in the temporary piping upstream of the flocculation tank.
    e. The dewatered sludge from the temporary unit will be conveyed to the adjacent Biosolids Storage Bay by a screw conveyor provided by the Supplier.
3. Existing Polymer System
    a. Temporary dewatering equipment will connect to existing plant polymer system.
    b. New polymer injection ring and inline mixer provided with screw press shall be installed for temporary operations as shown on contractor drawings.
4. Filtrate Effluent
    a. The Filtrate effluent will be routed to plant drain via 6” drain cleanout just north of the Biosolids Storage area.
5. System Operation and Maintenance:
    a. The facilities supplied will be operated by the Owner.
    b. The facilities will be maintained by the Contractor.
6. In the event that the dewatering facility (temporary or otherwise) is not available to Owner such that Owner is prevented from dewatering the sludge produced at the plant, the Contractor shall haul the liquid sludge produced to an alternate wastewater facility for processing at that facility. Should the Contractor be non-responsive to this, and CRWWD is forced to haul liquid sludge by its own means from the SCTP to and alternate wastewater facility for processing, liquidated damages will apply. These liquidated damages are defined in the General Conditions of the Construction Contract.

E. Design Criteria

1. The temporary units shall be provided with sufficient capacity to dewater all digestated sludge produced under the following anticipated operating conditions at SCTP.
2. The temporary dewatering facility shall be configured to fit within the Biosolids Storage Bay shown in Contract Drawings.

F. Operating Conditions and Requirements

1. Operating Conditions and Requirements

Parameter	Value
Sludge Feedstock, %TS	1.7 - 2.8
VS in feed sludge, %	70 – 80
Minimum solids production, dry lbs/hour	900
Anaerobically digested sludge production, gallons per day	60,000
Press volumetric capacity (1.7% feed)	105
Press volumetric capacity (2.8% feed)	65
Solids capture, minimum, percent	90
Dewatered Cake Solids, minimum, percent	16
Maximum polymer consumption, active polymer/DT	45
Available washwater pressure, psig	60 – 90
Maximum wash water usage, gallons per minute	100
Available polymer dilution water pressure, psig	60 – 90
Dewatered Cake Conveyance, dry lbs per hour	850
Dewatered Cake Conveyance, wet lbs per hour	5,400
Dewatered Cake Conveyance, cubic feet per hour (at 70/lbs per cubic foot density)	75

2.03 TEMPORARY FACILITY COMPONENTS

A. General

1. The Contractor is responsible for installing the screw press, temporary conveyor and all ancillary equipment required for operation of the dewatering system within the Biosolids Storage area.
2. The temporary facility area shall be located within the Biosolids Storage area as indicated in the Drawings.

B. Operating Platforms and Enclosures

1. Operating platforms shall be provided with stairs, handrails, and other appurtenances required for a safe operating environment, including adequate headroom.
2. Contractor shall provide all platforms, handrails, stairs, and all other appurtenances installed adjacent to the screw press system.

C. Process Mechanical

1. Screw Press

a. The screw press has supplied shall meet the requirements specified in Section 46 76 27.
b. The Contractor shall in use Screw Press 2, 72SCP2720 for the temporary dewatering system.
c. The Contractor shall install the screw press and all ancillary equipment for the temporary dewatering service. Following the installation of the permanent dewatering screw press in Building 72, the Contractor shall remove and relocate the screw to be installed for permanent dewatering.
    1) The Contractor shall be responsible for any damage and repairs to the screw press during the installation, removal and reinstallation of the screw press.

2. Conveyor System
    1) The Owner has pre-selected Fukoku Kogyo Company (FKC) as the supplier for the temporary conveyor system.
    2) The design of the temporary conveyor shall be the responsibility of the Manufacturer to meet the conveyance requirements specified in this Section.
        a) The Manufacturer shall supply either a shafted or shaftless screw conveyor for the temporary system including conveyor supports and inlet hopper from the screw press to the conveyor.
        b) The Contractor shall design and install the conveyor system to meet the requirements specified in this Section and as shown in the Drawings.
        c) Following temporary dewatering the conveyor shall be removed and salvage.

D. Electrical Service
1. General:
    a. Temporary electrical service shall comply with all applicable codes. The temporary power supply and control cables from the Contractor's service entrance to the temporary facility must be located so as not to interfere with construction activities and plant operations.
    b. Electrical systems and components shall comply with the requirements of Section 26 05 00 - Common Work Results for Electrical.
    c. Where wall penetrations are required, these shall be sealed with the appropriate fire seal to preserve the wall fire rating. Conduits exposed to sunlight shall be metallic.
    d. Following deactivation of the temporary facility, all temporary conduit/wiring and fastening equipment shall be removed and the Filter Building restored to original conditions. The electrical equipment shall be located such that modifications to the building (walls, ceilings, floors) are minimized.
    e. Following deactivation of the temporary facility, any newly installed bucket(s) or upgraded breaker(s) shall remain in place at MCC-5B. Associated raceways or tray cables shall be removed and removed from the site. Conduit risers that require to be installed from MCC- 5B to the cable tray, these shall remain as long as these are as specified on this project or match the existing materials. Wall sleeves shall be filled with removable foam or insulation and the ends sealed with a rated cover. Home runs to equipment shall be removed.

2. Dewatering Equipment:
    a. The Contractor shall provide temporary electrical service for the temporary facility from the Main Control Panel 72LCP2601 (installed in its final location).
    b. Provide power, control, and data cables from the Main Control Panel 72LCP2601 to the temporary dewatering equipment. The power, control, and data cables shall be routed to the temporary facility using the building mezzanine cable tray system where possible.
3. Conveyance Equipment
    a. The conveyance equipment shall be connected to the power supply via a spare breaker, where available, on the motor control center panel (MCC-5B) in the electrical room. In the event that the spare breakers are undersized, new MCC buckets with the required breaker of needed size shall be procured and installed to accommodate the load current of each equipment. Verify spare buckets for availability and to determine if their sizes are adequate to feed the temporary loads.

E. Instrumentation and Controls
1. Temporary facility shall be provided with instrumentation, control devices, and all wiring and appurtenances necessary to achieve the following functions:
    a. Operator initiated start-up and shut-down of the dewatering machines; operator initiation of the start/stop sequence via the PLC shall initiate a sequence as recommended by the Contractor, to start/stop related components of the system, i.e. wash water system, polymer feed system, etc.
    b. Operator initiated start of the feed pumps, polymer pumps, and wash water booster pumps; operator initiation of the start/stop sequence via the PLC shall initiate a sequence as recommended by the Contractor.
    c. Operator initiated start of the batch polymer mixing systems via the PLC.
    d. Automatic emergency shut-down of the systems, with annunciation of a visual and audible alarm located outside the temporary facility.
    e. Electrical interlock wiring between the dewatering units if separate control panels exist for each unit.
2. The temporary facility shall be provided with a local control panel (72LCP2601T) with HMI. Provide a data connection from the local control panel 72LCP2601T to the Main Control Panel 72LCP2601. Mirror the graphical display from the Main Control Panel HMI on the display of 72LCP2601T, and provide all control capabilities at the local control panel 72LCP2601T. Provide power to the local control panel 72LCP2601T in accordance with Section 26 05 00 - Common Work Results for Electrical.

F. Construction Materials
1. Contractor shall construct the temporary piping for the facility using the acceptable materials provided in the below table:

Temporary Piping Component	Acceptable Construction Material(s)
Digested Sludge	Lined DIP, SS 316,
Polymer	Schedule 80 PVC, CPVC
Washwater	HDPE, PVC
Filtrate	HDPE, PVC

PART 3 EXECUTION

3.01 INSTALLATION

A. The temporary dewatering facility shall be installed in accordance with this specification, the contract drawings, and the approved submittal information specified in paragraph 1.06. Any deviations from the approved submittal shall be completed only with the prior approval of the Engineer.

3.02 EQUIPMENT OPERATOR

A. The temporary dewatering facility will be operated by the Owner. The Owner will operate the equipment typically 10 hours per day 7 days a week.

B. Prior to commencement of the temporary dewatering facility, all operators shall be trained in the correct use of the equipment in a one day training session by a certified technician provided by the supplier. Additionally, the supplier shall provide this technician to work with the plant personnel over the first 5 days of use of the temporary dewatering facility. The supplier shall also provide this technician one day every 3 weeks thereafter for equipment use review.

3.03 PREOPERATIONAL CHECKOUT AND TESTING OF THE TEMPORARY DEWATERING FACILITY

A. Prior to making the temporary dewatering facility available to the Owner for use, the Contractor shall fully test each component of the facility to ensure that it is ready for operation and is capable of meeting the design criteria specified in paragraph 1.03.

B. The Contractor shall allocate a minimum of 10 working days in its schedule for these check-out and testing activities. The Contractor shall make any adjustments necessary to the temporary facility in order to comply with the specified design criteria, including but not limited to replacing equipment that does not perform. No additional contract time will be granted to the Contractor for making necessary adjustments or replacements.

C. Once the temporary facility is fully tested and has demonstrated the ability to meet the specified criteria, the Contractor shall submit a brief report documenting the testing performed and the results. Changes to the temporary facility from that documented in previous submittals shall be documented and included in a re-submittal to the Engineer.

3.04 MAINTENANCE OF TEMPORARY DEWATERING FACILITY

A. The Contractor is responsible for maintaining the temporary dewatering facility so that they are available for use by the SCTP staff to meet sludge dewatering needs. The temporary facility is critical to the plant's ability to produce effluent within their permitted limits and critical to maintaining odor levels in and around the plant within acceptable levels.

B. Maintenance of the temporary facility is grouped into 2 categories:
   1. Routine maintenance, including preventative maintenance and repair of items that are not critical to operation, and
   2. Emergency repairs.

C. Routine and preventative maintenance shall be conducted during periods when dewatering is not conducted by plant staff. Routine and preventative maintenance shall be performed generally between 2:00 PM and 5:00 AM, Monday through Saturday and on Sundays. The Contractor is responsible for conducting all maintenance within this period, unless approved at least 5 working days in advance by the Engineer. Routine maintenance shall include, but not be limited to, lubrication, adjustments, cleaning and replacement of wearing parts.

D. Breakdown of any component of the temporary facility places the SCTP at risk of an effluent violation. Consequently, any breakdown that limits the operation of the temporary facility such that Owner is prevented from processing the daily required sludge, must be corrected (i.e. making the temporary facilities ready for operation to the specified performance requirements specified herein) by the Contractor within 24 hours of notification of the need for an emergency repair from the Owner or the Engineer. To comply with this requirement, the Contractor shall maintain spare parts and/or equipment on-site and ready for use to correct an emergency maintenance condition.

E. Should the Contractor fail to comply with the above specified emergency repair requirements, the Contractor shall be obligated to haul liquid sludge beginning 48 hours after the notification of the need for emergency repair. The Contractor shall haul the liquid sludge produced at the plant to the Central Water Reclamation Facility at their expense. If the Contractor is non-responsive to hauling liquid sludge, then the Owner shall be entitled to take whatever action is necessary to remove sludge from the SCTP and the cost of these actions shall be deducted from future pay requests by the Contractor. For purposes of this provision, the costs for removing sludge from the SCTP under these emergency conditions is $0.10 per gallon of liquid sludge removed from the plant. Reference the liquidated damages part of these contract documents.

3.05 DURATION OF OPERATION

A. The temporary dewatering facility shall be made fully operational, documented with the report specified in paragraph 3.02 above, prior to any demolition work commencing in the Solids Processing Building except for the installation of temporary piping. Once demolition of the existing dewatering facility begins, the temporary facility shall remain operational through commissioning of the new dewatering equipment, plus 10 working days. The Contractor shall provide the Engineer with written notification of its intent to decommission the temporary facility not less than 10 working days in advance of the date when the decommissioning is to commence. Prior to the date of temporary facility decommissioning, the Contractor shall remain responsible for maintaining the temporary facility in an operationally ready state in accordance with this specification.

END OF SECTION

SECTION 46 76 27

SCREW PRESS DEWATERING SYSTEMS

PART 1 GENERAL

1.01 SUMMARY

A. Scope:

1. This section specifies the screw press dewatering systems, complete with screw presses, floc tanks, floc tank mixers, polymer injection rings, solenoid valves, instruments, control systems and control panels (including, but not limited to electric motors, variable frequency drives (VFD), control panels, shafts, safety guards, speed gear reducers, sludge conditioning devices, and spare parts) for the design, assembly, delivery, installation supervision and inspection starting and testing of the screw press equipment.
2. This specification is used for the design and performance criteria for the FKC screw press system that was pre-selected by the Owner. The contractor shall coordinate with the pre-selected manufacturer for all requirements stated in this specification.

B. Type:

1. Equipment furnished under this section shall be suitable for dewatering anaerobically digested sludge at a municipal wastewater treatment plant and located indoors in an unclassified, non-environmentally controlled building.

C. Equipment List:

Item	Equipment Number
Screw Press 1 Control Panel	72LCP2601
Screw Press 1 Floc Tank	72T262610
Screw Press 1 Floc Tank Mixer	72MIX2610
Screw Press 1	72SCP2620
Screw Press 2 Control Panel	72LCP2701
Screw Press 2 Floc Tank	72T262710
Screw Press 2 Floc Tank Mixer	72MIX2710
Screw Press 2	72SCP2720

1.02 QUALITY ASSURANCE

A. This section contains references to the following documents. They are a part of this section as specified and modified. In case of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.

Reference	Title
ABMA 9	Load Ratings and Fatigue Life for Ball Bearings
ABMA 11	Load Ratings and Fatigue Life for Roller Bearings
AISC	American Institute of Steel Construction –Manual of Practice
ANSI/ASME B46.1	Surface Texture, Surface Roughness, Waviness and Lay
NEMA 250-85	Enclosures of Electrical Equipment
IEEE 112	Polyphase Induction Motors and Generators

Reference	Title
UL 508A	Industrial Control Panels
NFPA 79	Electrical Standard for Industrial Machinery
NEMA ICS 6	Enclosures for Industrial Controls and Systems

B. Structural Design Standards:
   1. All steel structural components shall be so designed that the stresses developed under the specified conditions will not exceed the allowable stresses defined by the AISC standards and the above-mentioned standards.

C. Equipment Manufacturer's Experience:
   1. Company specializing in manufacturing products specified in this section with minimum three (3) years' documented experience and at least eight (8) screw presses 1.0 meter in diameter or larger in operation or under contract in North America.
   2. Company manufacturing products specified in this section shall have a minimum of eight (8) Service Technicians who are direct full-time, fully-trained employees of the equipment manufacturer and not provided for by a local dealer, distributor or other contract.

D. Provide services of factory-trained Service Technician, specifically trained on type of equipment specified:
   1. Service Technician providing requested services must have a minimum of five (5) years of experience, all within the last seven (7) years, on applicable type and size of equipment.
   2. Service Technician must be present on site for all items listed below. Person-day requirements listed are exclusive of travel time, and do not relieve the equipment manufacturer of the obligation to place equipment in operation as specified.
   3. Factory Acceptance Test: Verify proper operation of all system components, including the screw presses, floc tanks, and electrical/control panels prior to shipping.
      a. 2 person-days
   4. Installation: Inspect grouting, supports, location of anchor bolts; setting, leveling, alignment, field erection; coordination of electrical and miscellaneous utility connection:
      a. 10 person-days.
   5. Field Functional Testing: Calibrate, check alignment and perform a functional test. Tests to include all items specified.
      a. 3 person-days.
   6. Field Optimization: Optimize press setpoints, polymer consumption, polymer mixing, and any other system settings to reach specified performance.
      a. 5 person-days.
   7. Field Performance Testing: Inspect and monitor equipment during specified initial operation and acceptance testing.
      a. 2 person-days exclusive of optimization time.

8. Vendor Training: Provide classroom and field operation and maintenance instruction including all materials, slides, videos, handouts and preparation to lead and teach classroom sessions.
    a. 10 person-days total, 2 trips
9. Credit to the Owner all unused service person-days specified above, at the equipment manufacturer's published field service rate.
10. Any additional time required of the factory trained service technician to assist in placing the equipment in operation, or testing or to correct deficiencies in installation, equipment or material shall be provided at no additional cost to the Owner.

E. Provide all components made of stainless steel in accordance with paragraph 2.11.

1.03 SUBMITTALS

A. General Requirements:
    1. The following information shall be provided in accordance with Section 01 33 00.
    2. With every submittal, provide a copy of this specification section, with addendum updates included, and all referenced and applicable sections, with addendum updates included.
        a. Provide this specification with each applicable paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements.
        b. Check marks shall denote full compliance with a paragraph as a whole. If deviations from the specifications are indicated and, therefore requested by the equipment manufacturer, each deviation shall be underlined and denoted by a number in the margin to the right of the identified paragraph. The remaining portions of the paragraph not underlined will signify compliance on the part of the equipment manufacturer with the specifications.
        c. The submittal shall be accompanied by a detailed, written justification for each deviation.
        d. Failure to include a copy of the marked-up specification sections, along with justification(s) for any requested deviations to the specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration.

B. Informational Submittals
    1. Certificate of Unit Responsibility attesting that the equipment manufacturer has accepted unit responsibility in accordance with the requirements of this section. No other submittal material will be reviewed until the certificate has been received and found to be in conformance with these requirements.
    2. Experience statement with list of installations.
        a. Provide listing of five reference installations with contact names, mail addresses, and telephone numbers.
    3. The latest ISO 9001 series certification.

C. Shop Drawing Submittals

1. General Requirements:
    a. Provide a copy of the contract documents relating to the submitted equipment, with addendum updates that apply to the equipment in this section, marked to show specific changes necessary for the equipment proposed in the submittal. If no changes are required, the drawing or drawings shall be marked "no changes required". Failure to include copies of the relevant drawings with the submittal shall be cause for rejection of the entire submittal with no further review.
    b. Provide certified shop and erection drawings. Submit electronic files of the proposed equipment in the capacity, size, and arrangement as indicated and specified.
        1) Electronic files shall conform to the following minimum requirements:
            a) Electronic Files: AutoCAD 2022 and PDF latest version, drawn to scale.
            b) Submit electronic files as part of the Shop Drawing submittal.
2. Process/Mechanical Shop Drawings
    a. Drawings shall include plan views, sectional views, title block, tag numbers, serial numbers, parts list (identifying each component), dimensions, connection sizes and types and all details of all related items. In cases where certain information is proprietary and is omitted, provided a statement indicating that the information is proprietary and is being omitted.
    b. Plan, section, and P&ID drawings including location of all piping, electrical, instrumentation, supports, and structural connections.
    c. Drawings showing materials of construction, thicknesses, operating and maintenance envelope and key component and assembly weights.
    d. Certified setting plans, with tolerances, for anchor bolts.
    e. Complete weight of screw presses and foundation point loads for both empty and fully loaded presses. Identify any dynamic or vibration loads transmitted to foundation or supporting structure.
3. Electrical, Instrumentation, Controls Shop Drawings
    a. Electrical elementary diagrams, internal connection diagrams, and external interconnection diagrams, drawn in accordance with ICS standards. Connection diagrams shall be the conventional type with lines showing point-to-point wiring and must show terminals and devices as viewed by the Supplier/Subcontractor; wireless or wire schedule types are not acceptable.
    b. Electric motor control schematics for motor and VFD control.
    c. Cable Schedule.
    d. Local Control panel (LCP) layout drawings indicating the front door and panel equipment arrangement and dimensions and LCP wiring drawings demonstration power distribution and all other internal connections. Indicate customer connections, including network connections.
    e. Complete system interconnection diagrams between power supply, control panel, motors, VFDs, and all related components and customer connections for control. Include PLC input/output (I/O) diagrams.
    f. Detailed written control description with references to the P&IDs. Include descriptions of all functions monitored, controlled, and alarmed as it pertains to the equipment supplied.

D. Product Data Submittals
   1. General Requirements:
      a. Submit Product Data Submittal within 5 days of submitting the Shop Drawing Submittal
      b. Where the content of submitted literature from manufacturers includes data not pertinent to this submittal, clearly indicate which portion of the contents is being submitted for the Engineer's review.
   2. Process/Mechanical Product Data
      a. Detailed listing of screw press and ancillary equipment components and materials.
      b. Material Certification:
         1) Provide certification from the equipment manufacturer that the materials of construction specified are recommended and suitable for the service conditions specified and indicated. If materials other than those specified are proposed based on incompatibility with the service conditions, provide technical data and certification that the proposed materials are recommended and suitable for the service conditions specified and indicated including an installation list of a minimum of three (3) installations in operation for a minimum of five (5) years. Provide proposed materials at no additional cost to the Owner.
         2) Where materials are not specified, provide technical data and certification that the proposed materials are recommended and suitable for the service conditions specified and indicated.
      c. Equipment manufacturer's literature as needed to supplement certified data.
      d. Data regarding equipment performance and motor characteristics and performance.
      e. Gear reduction unit catalog data including service factor, efficiency, torque rating, service factor, AGMA classification and materials.
      f. Bearing temperature operating range for the service conditions specified.
      g. Bearing Life: Certified by the equipment manufacturer at the design conditions listed herein.
      h. Lubrication data including quantities required and product provided.
      i. All utility requirements for screw press operation, including, but not limited to, compressed air and plant water. Provide any quantity, pressure, and quality requirements for each utility.
      j. Equipment manufacturer’s product data, specifications, and color charts for shop painting.
      k. Shop drawing data for accessory items.
      l. List of recommended spare parts other than those specified.
   3. Electrical, Instrumentation, Controls Product Data
      a. VFD data including:
         1) Product Data, including marked manufacturer data sheet, dimensions, weight.
         2) Schematic diagrams and wiring connection diagrams showing functions and identification of terminals.

b. Motor data including:
    1) Marked manufacturer Motor Data Sheets
    2) Motor mounting, outline, dimensions, and weight
    3) Motor nameplate data (power rating, horsepower, voltage, full load current)
c. Instrumentation List including tag name, drawing number, manufacturer, and model.
d. I/O List including tag name and I/O designation (Rack, Slot, and Channel).
e. Catalog data on all instrumentation and applicable appurtenances, such as manifold valves, thermowells, bridles, etc.
f. Catalog data on all components installed within electrical panels and control panels including:
    1) Power Supplies
    2) Terminal Blocks
    3) Circuit Breakers
    4) Fuses
    5) Programmable Logic Controllers
    6) I/O Modules
    7) Communication Modules
    8) Network Switches

E. Action Submittal – Pre-Test Submittal
1. Factory Acceptance Test procedures and forms.
2. Field inspection reports and forms.
3. Programming
    a. One PDF copy of the printed programming logic
        1) Fully annotated with no non-functional code
4. OIT screens
    a. One PDF copy of all OIT screens and graphics

F. Action Submittal – Pre-Shipment Submittal
1. Equipment Factory Acceptance Test (shop test) results.
2. Motor Factory Acceptance Test (shop test) results.
3. Number, size, and weight of pieces shipped.
4. Recommendations for short and long-term storage.
5. Equipment weights and lifting points for installation and removal purposes.
6. Fabrication plan and schedule.
7. List of special tools for fabrication.
8. Field testing procedures, set up and equipment to be used.
9. Qualifications of field service engineer.
10. List of service person-days provided and per diem field service rate.
11. A copy of the equipment manufacturer's warranty.

G. Closeout Submittal
    1. As-built shop drawings and product data.
    2. Field Testing results
    3. Operating and maintenance instructions and parts lists per Section 01 78 23.
    4. As-Built programming
        a. One PDF copy of the printed programming logic
            1) Fully annotated with no non-functional code
        b. One electronic copy of the programming logic in native format.
    5. As-Built OIT screens
        a. One PDF copy of all OIT screens and graphics
        b. One electronic copy of the OIT graphical interface in native format.

1.04 NAMEPLATES

A. Nameplates shall be provided on each item of equipment. Equipment nameplates shall be 16-gauge Type 316 stainless steel bearing the equipment name and equipment number legibly engraved in ¾-inch high letters. Nameplates shall be attached to the equipment in an accessible location with Type 316 stainless steel screws.

1.05 GUARANTEED PERFORMANCE REQUIREMENTS

A. The Equipment shall be capable of operating as a Sludge Dewatering System, as shown on the Drawings to meet the following guaranteed performance requirements:
    1. The System shall receive, flocculate, condition, and dewater the feed sludge specified herein, and neatly discharge to the dewatered sludge cake conveyors as shown on the Drawings.
    2. The System shall operate continuously or intermittently on demand. The System shall be suitable for dewatering the specified sludge and shall perform the required dewatering operations at the loading and operating conditions specified herein.
    3. The System shall perform at the operating conditions and meet the guaranteed minimum performance requirements specified in Part 1.06 while treating the feed sludge produced at the Salmon Creek WWTP.
    4. The System shall utilize the existing polymer feed system including the Liquid Polymer Storage Tank (76T0601), Polymer Blend Unit (76M1002), Polymer Mixing Tank (76T6001), Polymer Feed Tank (76T5801), and Polymer Feed Pumps (76P201 and 76P6202). The existing system utilizes Clarifloc WE 2009. Alternate emulsion polymer may be used per manufacture's recommendation during the performance test. If alternate emulsion polymer is selected, the equipment supplier shall provide a one month supply of the selected emulsion polymer.
    5. The System shall utilize a connection to the existing 3W system. Manufacturer shall provide pressure control valves and solenoid valves as required for flushing.

1.06 PERFORMANCE REQUIREMENTS

A. Service and Operating Conditions

Operating Condition	Value
Operating days per work week	7
Operating hours per work day*	10
Type of Sludge	Anaerobically Digested Blended Waste Activated and Primary Sludge
Feed sludge dry solids concentration (TS)	1.7 – 2.8%
Feed Sludge temperature	4 degrees C to 38 degrees C
Feed sludge pH	6 to 8
Conditioning Flocculant	Emulsion polymer
Existing Polymer Feed Pumps, gpm	4 - 12
Wash water	Plant Utility Water (W3)
Available wash water flow rate per press, gpm	100
Available wash water pressure, psig,	90

* Equipment shall be designed for continuous operation 24 hrs/day, 7 days/week.

B. Guaranteed Performance Requirements

Item	Value
Total Solids Loading (Rated) Capacity	900 lb dry feed solids per hour per press[1]
Press volumetric capacity (1.7% feed)	105 gpm per press
Press volumetric capacity (2.8% feed)	65 gpm per press
Minimum Cake Solids Concentration	18%
Minimum System Solids Capture (SC)	92%
Maximum Polymer Dosage Rate	45 lb of active polymer per dry ton of sludge, at a maximum 1 percent polymer solution concentration

[1] *Solids loading shall be independent of sludge total solids feed.*

1. For the purpose of this specification, “Solids Capture (SC)” will be defined as:

   Solids Capture (SC) = [(C/F) x (F-T)/(C-T)] x 100

   Where: C = Cake TS (mg/kg)

   F = Feed TS (mg/kg) – where feed is defined as the sludge stream, excluding any dilution due to polymer solution addition.

   T = Filtrate TS (mg/kg) – where filtrate is defined as the stream attributable to the screw press dewatering of the sludge feed only, excluding any dilution due to polymer solution dilution and/or washwater.

1.07 GUARANTEE OF PERFORMANCE

A. It shall be the responsibility of the equipment manufacturer to provide personnel trained in the equipment proposed to demonstrate that the equipment performs as herein specified in the Guaranteed Performance Requirements. The equipment manufacturer’s qualified personnel shall be present at all times during the acceptance testing.

PART 2 PRODUCTS

2.01 GENERAL

A. The use of an equipment manufacturer's name and model or catalog number is for the purpose of establishing the standard of quality and general configuration desired only. All equipment and associated materials shall be new and without imperfections.

B. The equipment system shall be designed to extract water (dewater) from the anaerobically digested sludge specified herein after conditioning of the sludge with a solution of emulsion polymer. Dewatering by a screw press shall be accomplished by slowly squeezing the flocculated sludge and allowing the liquid to escape through perforated screens surrounding the screw while retaining the solids inside the press. The function of the screw press shall be to generate dewatered sludge such that the discharged cake solids concentration, polymer usage, and solids capture comply with the Guaranteed Performance Requirements specified herein.

C. The equipment shall be fully assembled and factory tested as far as practical prior to shipment. The Owner may elect to inspect the system prior to shipment. Equipment manufacturer shall notify Owner of all factory testing a minimum of 30 days prior to conducting tests.

D. The system equipment shall be oriented and configured as the equipment manufacturer's standard unit as shown on the Drawings. Manufacturers may propose an alternative arrangement in proposal if the arrangement shown on Drawings is not optimal for submitted equipment design.

E. All parts of the mechanisms shall be amply proportioned for all stresses that may occur during fabrication, shipment, erection, and operation.

2.02 MANUFACTURERS

A. All of the equipment described herein shall be supplied by the pre-selected manufacturer in order to provide unit responsibility.

B. Screw Press:
   1. Fukoku Kogyo Company (FKC), Model BHX-1350

C. Floc Tanks
   1. Floc tanks and mixers shall be provided by the pre-selected manufacturer and as specified herein.

2.03 CONSTRUCTION AND MATERIALS

A. All wetted elements of the equipment shall be fabricated from 304 stainless steel, or equally corrosion-resistant material. The principal elements of the equipment shall be fully assembled for simplified movement and installation.

B. Floc Tanks, Floc Tank Mixer Motors:
   1. The floc tanks shall be non-pressurized open-top design with a minimum volume of 540 gallons. The inlet pipe shall be fitted with an ANSI flange and located at the bottom of the tank. Conditioned sludge will discharge from the outlet pipe ANSI flange located near the top of the tank. Tank drain with valve shall be provided.
   2. The floc tank shall be equipped with a 6" nozzle for connection to the odor control system.
   3. The floc tanks shall be supplied complete with an agitator and fixed flow breakers. The agitator drive shall include electric motor and speed reducer. Agitator speed shall be controlled by a VFD supplied by the equipment manufacturer.
   4. The floc tank mixer motor shall be furnished as follows:
      a. UL Listed, squirrel cage induction motor.
      b. Motor Horsepower: 1.5 hp
      c. 480V/3 phase/60Hz, Totally Enclosed Fan Cooled (TEFC) Frame meeting IEEE 841 standards, suitable for variable speed operation with a PWM constant torque inverter, NEMA Premium efficiency inverter duty rated, and severe duty motor with 1.15 service factor.
      d. Include lifting lugs on motors, stainless steel nameplate, cast iron housing and conduit box, corrosion resistant hardware, and the manufacturer's standard corrosion resistant epoxy finish.
   5. Variable frequency drive for the Floc Tank Mixer shall conform to the requirements of paragraph 2.04 herein.
   6. Floc tank shall include level sensor. The sludge feed into the tank shall be automated, controlled and monitored by the control panel. Device shall have a 4-20mA analog output for process control to control feed pump speed.
   7. Floc tank mixer motor is powered and controlled from the vendor-provided local control panel.

C. Screw Presses, Screw Press Motors:
   1. The screw presses shall be horizontal screw presses and shall include the following components and features.
      a. Screw press with screw
      b. Removable press screen basket
      c. Screen spray cover with hinged inspection doors
      d. Speed reducer
      e. Direct mounted drive motor
      f. Washdown mechanism
      g. Flanged filtrate and cake solids outlets
      h. Cake solids chute
      i. Cake discharge sample port
      j. Cake solids chute and piping flexible connectors
      k. Adjustable back pressure cone

2. Screw press assemblies shall consist of a cylindrical perforated screen basket with two longitudinal flanges to permit disassembly for service; screens shall be horizontal to the ground, not inclined. Internal screw shall generate increasing pressure on the sludge during the axial passage of the sludge through the press to achieve dewatering. Screw flights shall be welded to the shaft and shall not be bolted or removeable. Screw flights shall be designed to maintain dewatering performance without a wearable elastomeric seal on the tip of screw flight. Provide manufacturer's recommended clearance between screw flight and screen.
3. Screw press "wetted" parts including cake solids chute shall be constructed of 304 stainless steel throughout. Screw press structural base and other "non-wetted" parts shall be constructed of 304 stainless steel or carbon steel with the equipment manufacturer's standard corrosion resistant coating.
4. Each screw press shall be equipped with minimum of three (3) 6-inch vents to be connected to the odor control system.
5. The screw press drive motor shall be furnished as follows:
    a. UL Listed, squirrel cage induction motor.
    b. Maximum Motor Horsepower: 7.5 hp
    c. 480V/3 phase/60Hz, TEFC Frame meeting IEEE 841 standards, suitable for variable speed operation with a PWM constant torque inverter, NEMA Premium efficiency inverter duty rated, and severe duty motor with 1.15 service factor.
    d. Include lifting lugs on motors, stainless steel nameplate, cast iron housing and conduit box, corrosion resistant hardware, and the manufacturer's standard corrosion resistant epoxy finish.
6. The press equipment shall be supplied with a geared speed reducer direct coupled/mounted to drive motor on input and screw press shaft on output. The presses shall be driven from the discharge end of the screw press units.
7. Variable frequency drive for screw press main drive shall conform to the requirements of paragraph 2.04 herein.
8. Any couplings and other high-speed rotating parts shall be provided with OSHA approved guards, unless otherwise enclosed by design (e.g., direct coupled).
9. The screw presses shall be provided with removeable lightweight stainless-steel spray cover for the top and sides of the screw press for sanitation and personnel protection.
10. All piping connections shall be either ANSI, class 150, standard raised face flanges or NPT threaded.
11. Cake solids connection shall be bolted and flanged.
12. Washdown mechanism shall be a circular pipe manifold with an array of spray nozzles to clean the exterior of the screw screen. The manifold transits along the cylinder axis and shall be actuated by a pneumatic positioner. Wash water shall be plant utility water. Frequency of wash cycle shall be twice per 12-hour operating shift approximately every 6 hours, configurable and controlled at the press control panel including the number of simultaneous press wash cycle events for all active screw presses. Wash water pressure shall be 60 psi minimum during wash cycle.

13. All mechanical and electrical connections to the screw press, including, but not necessarily limited to, the feed sludge, centrate and cake solids, sample line, and electrical raceways shall be equipped with flexible connections supplied by the equipment manufacturer as required. All flexible connections shall isolate screw press vibrations from fixed, rigid external connections. No external loads shall be transferred to a screw press by external connections to the machine. Cake solids flexible connection shall be flanged and fabricated from neoprene, with Type 316 stainless steel bolts with Type 316 stainless steel retainer plates at each end. Piping flexible connectors shall be metal reinforced elastomer with flanged connections. Tubing flexible connectors shall be Type 316 stainless steel braided hose.
14. Chute for solids discharge shall be designed to provide a smooth interior surface for optimum vertical transport of solids without buildup.
15. The screw presses will be installed on support frame at an elevation that permits discharge into screw conveyor. Support frame dimensions will be determined during final design.
16. Equipment manufacturer shall provide all necessary dimensions that are fully coordinated with all cross conveyor interface requirements to allow for the proper design of adjacent free standing platforms and stairs provided by others to accommodate press access.
17. Press equipment shall be supplied with a lifting device (spreader bar), to accommodate performing removal, replacement, and maintenance activities and shall be fully coordinated with the crane high hook position. Maximum spreader bar height shall be 21 inches and sized for the supplied screw press element.

D. Polymer Injection Rings
   1. Polymer injection rings shall be provided for primary polymer injection upstream of the mixing tank.
   2. Injection wafers shall be designed to be installed between flanges using ring style design which fits within the bolt circle of the flange bolts.
   3. Injection ports shall be full diameter through the injection wafer. The use of diffuser style ports at injection points is not permitted.
   4. Design requirements:

Injection Ring Information	Value
Type	Primary
Location	Upstream of floc tank
Process pipe connection diameter, inches	6
Flow rate, gpm	52
Ring thickness, inch	2
Materials of construction	Stainless Steel, AISI Type 304 or Acetal(Delrin)
Number of ports	4
Port Diameter, inches	1
Port connection type	threaded

2.04 VARIABLE FREQUENCY DRIVES

A. Floc Tank Mixer Drive
   1. The floc tank mixer drive system shall consist of an electric motor coupled to a speed reducer and suitable for use with a variable frequency drive (VFD) system as required to provide full load capacity and also to withstand the full starting torque of the system. Floc tank mixer shall be electronically controlled by means of a VFD.
   2. The system size and torque requirements shall be in accordance with the screw press manufacture's design requirements of the driven equipment.
   3. Communication options to, at a minimum, include options below:
      a. Analog I/O as required to meet the operational requirements of the control description.
      b. Discrete I/O as required to meet the operational requirements of the control description.
      c. Ethernet Communication supporting Ethernet IP network protocol.
   4. VFD shall be integral to the LCP (local control panel) provided with screw press system.
   5. Manufacturer: Provide VFD to meet operational and performance requirements.
      a. Allen Bradley PowerFlex
      b. Or approved equal

B. Screw Press Drive
   1. The screw press drive system shall consist of an electric motor coupled to a speed reducer and suitable for use with a variable frequency drive (VFD) system as required to provide full load capacity and also to withstand the full starting torque of the system. Screw speed shall be electronically controlled by means of a VFD.
   2. The system size and torque requirements shall be in accordance with the screw press manufacture's design requirements of the driven equipment.
   3. Communication options to, at a minimum, include options below:
      a. Analog I/O as required to meet the operational requirements of the control description.
      b. Discrete I/O as required to meet the operational requirements of the control description.
      c. Ethernet Communication supporting Ethernet IP network protocol.
   4. VFD shall be integral to the LCP (local control panel) provided with screw press system.
   5. Manufacturer: Provide VFD to meet operational and performance requirements.
      a. Allen Bradley PowerFlex
      b. Or approved equal

2.05 LOCAL CONTROL PANELS

A. Description:
   1. Provide one local control panel (LCP) for each screw press.
   2. Local control panels shall contain operator control devices, control relays, indicating lights and other panel devices to provide the specified system operation as specified herein.
   3. Local control panels shall contain:
      a. Starters and Drives
      b. Programmable Logic Controller (PLC)
      c. Panel mounted Operator Interface Terminal (OIT)
      d. Ethernet switch
      e. Any hardwired control logic required
      f. Panel enclosure ventilation, heating, and cooling as required. Maintain NEMA rating.
   4. Integrate motor starters, VFDs, the PLC, OIT and other required devices into the design of the control panel.
   5. The LCP will serve as the source of power, communication, and control for all of the equipment supplied by the vendor.
   6. Screw press system and equipment will be installed in a wet and corrosive environment. All electrical components associated with the system shall be suitable for this harsh environment. Junction boxes and other electrical devices required shall be provided with NEMA 4X 316 SST enclosures.
   7. The local control panels will be mounted remotely, but within the same room as the screw presses.

B. Performance/Design Criteria
   1. Approvals/Listing: UL 508 Approved
      a. The local control panels shall bear the UL 508 label. The UL label shall apply to the enclosure, the specific equipment supplied within the enclosure, and the installation and wiring of the equipment within and on the enclosure. The fabricator shall be an approved UL listed manufacturer.
   2. Power Supply to Cabinet: Single Source 480 Vac, 60 Hz, 3 Phase
   3. The panel shall include a main circuit breaker with flange type disconnect handle. The Short Circuit Rating of unit shall be 65 KAIC.
   4. Include surge protection at power supply connection in the LCP.
   5. Configure where upon loss of power and return of power the system shall return to the ready state.
   6. Control Power:
      a. Provide 480 VAC to 120 VAC transformer for control power. Provide primary and secondary fuses.
      b. Provide 24 VDC power supply
         1) Operate controls at 24 VDC volts supplied from power supply.
         2) Provide primary and secondary fuses.

c. Provide UPS and battery within the local control panel.
    1) 24 VDC input
    2) 24 VDC output
    3) UPS shall provide backup power for PLC components, Network components, and loop-powered Instrumentation.
    4) Provide power calculations demonstrating available standby power for 5 minutes upon loss of line power.

7. Separate 24 VDC and 120 VAC control power components from 480 VAC power components using a painted metal barrier. 480 VAC to 120 VAC transformer shall be located on the 480 VAC side of the metal barrier.
8. Ventilation
    a. Provide a ventilation system (fan and intake) and Maintain NEMA Rating of the panel.
9. All components in the control panel:
    a. Shall be completely factory wired.
    b. Shall be finger safe.
    c. All external control connection points shall terminate on a terminal strip. There shall be a minimum of 20% spare terminal connections supplied.
10. Drives (VFDs)
    a. Install the drives for the Screw Press motor and Reaction Rank Mixer motor on the 480 VAC side of the barrier in the LCP.
    b. Include all circuit protective devices for the VFD and Motor within the LCP.
    c. Include complete control power system including transformer and auxiliary devices for control of the circuit within the LCP.
    d. Provide an externally mounted reset button for the VFD.
11. PLC
    a. Power the PLC with 24 VDC Control Power, backed up by UPS.
    b. The PLC shall interface via Ethernet to the plant-wide control systems.
    c. For Discrete Inputs and Discrete Outputs interfacing with power sources that is not 24VDC control power originating from the LCP, provide interposing relays.
    d. The PLC shall interface via Ethernet to the plant-wide control systems and include the following:
        1) Provide a contiguous list of data for monitoring and control from SCADA.
        2) Provide interlock and alarm data for each individual data point to alert operations via SCADA of the particular issue and or alarm.
        3) Equipment data shall also include elapsed time, yesterday's run hours and today's run hours in tenths of hours.
        4) Provide a PLC clock synchronization provision.
        5) Provide heartbeat logic for network monitoring status to SCADA.
12. OIT
    a. Power the OIT with 24 VDC Control Power, backed up by UPS.
    b. The following status shall be displayed on the OIT:
        1) System Run indicator (Red)
        2) System Off indicator (Green)

3) System Fault indicator (Amber)
4) Screw Press Feed Pump Flow rate (from SCADA)
5) Run indicator for each motor (Red)
6) Off indicator for each motor (Green)
7) Fault indicator for each motor (Amber)
8) High motor torque and overload for each motor (Amber)
9) High motor Temperature indicator for each motor (Amber)
10) Motor speed for each motor
    a) Can be adjusted if motor HOAs are in Hand
11) Headbox Level
12) Wash sequence status
13) Screw torque (or equivalent)
14) Alarm Banner with system alarms

c. The OIT shall allow the operator to run the Screw Press manually.

13. Network
    a. Power the network switch with 24 VDC Control Power, backed up by UPS.
    b. Provide connection from LCP to plant SCADA using Ethernet IP.
14. Pilot Devices
    a. Primary power on – indicating light (Grace products Model R-3W(2)-KB-L or equal)
    b. Control power on – indicating light (White)
    c. System Run light (Red)
    d. System Off light (Green)
    e. System Fault/Reset light pushbutton (Amber)
    f. HOA switch for each motor (Black)
    g. System E-Stop (Red Mushroom head Pushbutton with cover)

C. Materials or Components
1. Enclosure
    a. NEMA 4X
    b. Dimensions not to exceed 40in x 24in x 72in (W x D x H)
2. Main Disconnect Switch:
    a. Thermal magnetic circuit breaker, 65 KAIC.
    b. Circuit breaker handle, flanged type.
3. Surge Protection
    a. Vendor Standard
4. Control Power Transformer: Sized for load plus 50% spare capacity.
5. Control Power 24 VDC power supply
    a. 120 VAC input
    b. 24 VDC output
    c. Manufacturer: Phoenix Contact QUINT or approved equal.

6. Control Power UPS and battery
    a. UPS Manufacturer: Phoenix Contact QUINT or approved equal.
    b. UPS Battery Manufacturer: Phoenix Contact UPS-BAT or approved equal.
7. Wire management:
    a. Slotted wall wire duct
8. Control Relays:
    a. Provide LED or mechanical status indication on Relay.
    b. Contacts rated 10 amps.
9. Fuse Terminals:
    a. Provide with blown fuse indicators.
10. Drives (VFDs)
    a. Provide VFDs for the screw presses and floc tank agitators.
        1) The drives for the Screw Press motor and Reaction Rank Mixer motor shall be as specified in paragraph 2.04.
11. Programmable Logic Controller (PLC)
    a. Manufacturer: Allen-Bradley CompactLogix without exception
    b. Networking Connections: Ethernet/IP
    c. Processor:
        1) Power Supply
            a) Mod Power: 24 VDC
            b) SA Power: 24VDC
        2) Memory:
            a) 0.6 MB or greater
            b) Memory shall be provided so that 50% is available after program is tested.
        3) Programming languages: Ladder Diagram, Function Block Diagram, Sequential Function Chart
        4) Built in Communication ports: one USB port, and two Ethernet (RJ-45) Ports
        5) Maximum Local IO Modules: 8
        6) Allen-Bradley CompactLogix 5069-L306ER or approved equal.
    d. Input and Output Modules:
        1) General: Compact 5000 I/O modules
        2) Discrete Inputs: 24 VDC, 16 channel.
        3) Discrete Outputs: 24 VDC, 8 channel.
        4) Relay Outputs: Normally Open, 8 channel.
        5) Analog Inputs: 4-20 mAdc, 24 VDC, 8 channel.
        6) Analog Outputs: 4-20 mAdc, 24 VDC, 4 channel.
        7) Spare Input/Output channels: 20 percent of each type provided per control panel.
    e. Provide all cables, taps, terminators, power supplies, and accessories for a complete operating PLC system.

12. OIT
    a. 10 inch TFT LCD Screen, Touchscreen
    b. NEMA 4X front panel
    c. Ethernet port
    d. Power: 24VDC
    e. Capable of displaying all data, graphics, and alarms.
    f. Manufacturer: Allen-Bradley PanelView 5000 or approved equal.
13. Network Switch
    a. Managed Industrial Ethernet Switch
    b. Input Power: 24 VDC
    c. Fast Ethernet Ports: 6 at minimum
    d. Manufacturer:
        1) Allen Bradley Stratix
        2) Cisco IE
        3) N-Tron
        4) Or approved equal managed switch.
14. Pilot Lights and Devices:
    a. Match enclosure NEMA rating.
    b. Heavy duty type: Watertight and corrosion resistant
    c. 30 mm.

D. Interfaces
    1. Provide pilot devices and OIT on the front door of each LCP enclosure.
    2. OIT shall be configured for connection to the PLC via the Ethernet IP.
    3. Provide network connection for complete monitoring and control to SCADA using Ethernet IP.
        a. Provide a read-only register map for all monitored data points.
        b. Provide ability to read data from the plant SCADA for proper function of the screw press.
    4. Provide hardwire connection for monitoring and control to SCADA for the following signals:
        a. See Control Description in paragraph 2.07.

2.06 INSTRUMENTATION

A. General:
    1. Screw press vendor shall provide the field instrumentation for the screw press system in order to monitor and control the screw press system. Instruments shall be suitable for the environment of installation.
    2. Screw press vendor shall provide the appropriate equipment protection devices. This may include overload, over-torque, low/high pressure, etc. Equipment shall be appropriately protected, and protection shall be incorporated into the controls systems provided by the vendor.
    3. Screw press vendor shall provide ancillary devices for system operation as required, including solenoid valves, actuators for control valves, and safety devices.

B. Instrumentation:
   1. Provide instrumentation per vendor standards for monitoring and control. In addition, include the following:
      a. Application: Screw Press Level
         1) Signal Output:
            a) Analog, 4-20mA HART
         2) Loop powered
         3) Diaphragm
            a) 316 stainless steel with 3-inch flush-mounted sensing surface
         4) Electrical Housing
            a) Aluminum
         5) Conduit Entry:
            a) 1/2-inch NPT
         6) Calibrated for required range
      b. Application: Floc Tank Level (Non-contacting)
         1) Signal Output:
            a) Analog, 4-20mA HART
         2) Loop powered
         3) Electrical Housing
            a) Aluminum
         4) Conduit Entry:
            a) 1/2-inch NPT
         5) Calibrated for required range

2.07 CONTROL DESCRIPTION

A. Provide a Control Description that describes the programming of the PLC and completely describes the following:
   1. All manual modes of operation
   2. All automatic modes of operation
      a. Each screw press shall be capable of operating either:
         1) a constant sludge feed flow/variable press speed control strategy
         2) or variable sludge feed flow/constant press speed control strategy.
   3. All Permissives and Interlocks:
      a. A screw press will automatically start only after all run permissives in a screw press train are satisfied. Provide a list of permissives for each mode of operation.
      b. If a screw press is running, it will stop if an interlock condition occurs. Provide list of interlocks for each mode of operation.
   4. All monitoring functions.
   5. All alarm conditions.

B. All monitored data points, alarms, and statuses of equipment shall be communicated from the screw press LCP to the Plant SCADA system over Ethernet connection. Provide a read-only register map for communication from the LCP to the plant SCADA.

C. All required inputs from Plant SCADA and all required outputs to Plant SCADA for correct function
   1. Include a summary list of all required inputs and outputs

D. Inputs from the Plant SCADA to the Screw Press LCP shall be communicated over Ethernet connection and shall include the following at a minimum:
   1. Sludge feed pump running status
   2. Sludge feed pump fault status
   3. Sludge feed flow to each screw press
   4. Polymer feed pump running status
   5. Polymer pump fault status
   6. Polymer flow to each screw press
   7. Wash Water pump running status
   8. Run status for each conveyor (assume up to 3 conveyors)
   9. Fault for each conveyor (assume up to 3 conveyors)

E. Provide Hardwire connections for monitoring and control to SCADA for the following signals:
   1. Screw Press Running Status
   2. Screw Press Fault Status
   3. SCADA Stop Command
   4. SCADA Start Command

F. Provide the ability to monitor and control the Screw Press Feed Pumps from the Screw Press Control Panels (specified herein) using the network connection from the SCADA system to the screw press control panels.
   1. Provide a screen on the panel-mounted HMI on the local control panels for the monitoring and control of the Screw Press Feed Pumps

2.08 PROGRAMMING REQUIREMENTS

A. Systems shall be monitored via the Ethernet/IP communications connection to plant SCADA.

B. Provide memory map of all internal registers in the PLC.

C. Provide manufacturer supplied memory map of all internal registers in the VFDs.

D. Provide control through hardwired PLC outputs by plant SCADA, and local equipment control panel as described in the control description.

E. Submit PLC program as described in the submittals portion of this specification section. The program shall be developed in RS Studio per Owner's plant standards. The program shall be ladder logic, function block, or sequential function chart. The program shall be

fully annotated with the program's intent on every logic rung, function block, and sequential step.

1. Submit proposed program under the Pre-Test submittal. Submit as-built programming under the Closeout Submittal.

F. Submit all OIT screens, navigation elements, faceplates, and other graphical elements as described in the submittals portion of this specification section. The OIT shall be developed in Ignition per Owner's plant standards.

1. Submit proposed OIT graphics under the Pre-Test submittal. Submit as-built OIT graphics under the Closeout Submittal.

2.09 ANCHOR BOLTS, FASTENERS AND EQUIPMENT MOUNTING

A. All anchor bolts shall be made of type 316 stainless steel. The equipment manufacturer shall furnish all anchor bolts, nuts, and washers required for the equipment. Anchor bolts shall be adhesive epoxy type.

B. All fasteners shall be made of type 316 stainless steel. The equipment supplier shall size and furnish fasteners required for the assembly of the equipment.

2.10 COATINGS

A. Screw press components shall be shop finish painted according to the equipment manufacturer's standard system for the application: Polyamide Epoxy Basecoat, Polyurethane Topcoat. Stainless steel surfaces shall remain unpainted.

B. Ferrous surfaces which are not to be painted shall be given a shop applied coat of grease or rust resistant coating.

C. Provide additional shop paint coating for touch-up to all surfaces after installation and testing is completed and equipment accepted.

2.11 PASSIVATION OF STAINLESS STEEL

A. General:

1. Equipment specified under this section shall be cleaned and passivated in accordance with methods defined in ASTM A380 – Standard Practice for Cleaning, Descaling, and Passivation of Stainless Steel Parts, and the specific requirements of this section.
2. For purposes of this section, cleaning and passivation is defined as the removal of surface contaminants including exogenous iron or iron compounds and the removal of oxide films from the surface of stainless steel by means of mechanical cleaning and mechanical descaling.
3. The processes specified in this section shall be performed in the manufacturer's facility or in a shop specializing in post fabrication treatment of stainless steel.
4. Equipment components that bolt together shall be disassembled prior to passivation to provide access to all surfaces of the equipment.
5. All fasteners and anchor bolts required for assembly and mounting of equipment shall conform to the requirements of Section 43 05 11.

6. The use of “fabricator’s crayons” shall be prohibited during fabrication of equipment as these marks may prevent proper passivation.

B. Passivation Process Requirements:
   1. The processes required for proper passivation shall include precleaning, mechanical descaling, and post-treatment inspection as defined below.
      a. Precleaning – Precleaning required for the removal of all grease, oil, paint, soil, grit and other gross contaminants preparatory to the fabrication process shall be accomplished by vapor degreasing, immersion or spray application of alkaline or emulsion cleaners, steam, or high pressure water jetting.
      b. Mechanical Cleaning and Descaling – Mechanical cleaning is the removal of surface contamination, exogenous iron and rust. Mechanical descaling is the removal of oxide films resulting from high temperature processes such as heat treatment and welding from the surface of stainless steel. Mechanical cleaning and descaling shall be accomplished by abrasive bead blasting but may also be supplemented with a combination of sanding, grinding, and power brushing to provide a surface that is smooth, uniform and free from all foreign matter, weld slag, corrosion, coatings, heat tint, discoloration, and mill scale. Grinding wheels and sanding tools should not contain iron, iron oxides, zinc or other materials that could contaminate the stainless steel surface. Abrasive blasting materials shall be iron-free silica or alumina sand. Blasting equipment previously used for cleaning carbon steel or other materials containing free iron shall be cleaned to prevent contamination of stainless steel passivation process. All surfaces shall be wiped clean following mechanical cleaning.
      c. Post Cleaning Inspection – Post treatment inspection of the part shall exhibit a clean, bright and uniform surface with no signs of etching or pitting from the abrasive blasting procedure. All traces of oxide films from high temperature processes shall have been removed.

2.12 SAFETY ITEMS

A. All equipment furnished shall be manufactured to comply with the most recent safety standards of the Federal Occupational Safety Health Act and all other applicable safety codes.

2.13 FACTORY ACCEPTANCE TEST DOCUMENTATION

A. All major system components shall be factory tested (shop tested) for proper function, and a certification of the results of these tests shall be submitted for review prior to shipment.
   1. Provide a FAT with the test and subsequent retests witnessed by the Owner or Owner Delegate, including the travel and accommodation costs for up to two witnesses.
   2. Load software and configuration for control system panels, controllers, operator interfaces, and the programming and graphic configuration application at the control system equipment supplier’s factory prior to the FAT.
   3. Inspect equipment, panel instruments, panels, or cabinets with factory testing performed.
   4. Verify all wiring according to panel wiring diagrams and complete a pull-test of all wire terminations

5. Provide written notice to the Engineer and Owner a minimum of 30 working days before the commencement of the FAT activity and include:
    a. Schedule for the FAT.
    b. Location of the FAT.
    c. Testing equipment used.
    d. Detailed test procedure with forms for the recording of test results.
    e. All panel drawings with incorporated submittal comments.
    f. Sign-off spaces for the individuals performing and witnessing the tests.

B. Provide motor shop testing documentation.

C. Provide Control Panel Testing documentation.
    1. Test all functions and alarms of each control panel.

2.14 PRODUCT DATA

A. The following information shall be provided as indicated:
    1. Operation and maintenance (O&M) manuals and data shall be provided in accordance with Section 01 78 23. O&M manuals shall be provided prior to delivery of the equipment.
    2. Three copies of Installation Certification Form 43 05 11-A as specified in Section 01 99 90 shall be provided prior to any testing of the equipment.
    3. Three copies of Training Certification Form 01 78 23-A as specified in Section 01 99 90 shall be provided immediately after completion of training.

2.15 SPARE PARTS

A. The following spare parts shall be provided:
    1. Four screen sections.
    2. One motor coupling.
    3. First filling of lubricants
    4. Ten of each fuse type and size used.
    5. Two of each relay type and size used.
    6. Five of each type pilot light/indicator used.
    7. One set of special tools if needed
    8. Spare parts shall be tagged and stored as specified in Section 43 05 11.

2.16 PRODUCT STORAGE AND HANDLING REQUIREMENTS

A. Equipment, products and materials shall be shipped, handled, stored, and installed in ways which will prevent damage to the items. Damaged items will not be permitted as part of the work except in cases of minor damage that have been satisfactorily repaired and are acceptable to the Owner.

B. Spare parts, wherever required by detailed specification sections, shall be stored in accordance with the provisions of this paragraph. Spare parts shall be tagged by project equipment number and identified as to part number, equipment manufacturer, and subassembly component (if appropriate). Spare parts subject to deterioration such as ferrous metal items and electrical components shall be properly protected by lubricants or desiccants and encapsulated in hermetically sealed plastic wrapping. Spare parts with individual weights less than 50 pounds and dimensions less than 2 feet wide, or 18 inches high, or 3 feet in length shall be stored in a wooden box with a hinged wooden cover and locking hasp. Hinges shall be strap type. The box shall be painted and identified with stenciled lettering stating the name of the equipment, equipment numbers, and the words "spare parts." A neatly typed inventory of spare parts shall be taped to the underside of the cover.

PART 3 EXECUTION

3.01 FACTORY ACCEPTANCE TESTING

A. Provide a 30-day minimum notice prior to testing and coordinate with Owner and Engineer witnessing of the Factory Acceptance Testing (FAT). Include 2-days minimum per representative for witnessing.

B. A service technician employed by the equipment manufacturer shall be present for a the entire FAT (minimum of two (2) consecutive days) to demonstrate and perform the FAT.

C. Conduct factory tests (shop tests) to verify proper operation of all system components, including the screw presses, floc tanks, motors, drives, and electrical/control panels prior to shipping.

D. Submit complete testing documentation for review prior to shipment.

E. Repeat tests until specified results are obtained.

F. Correct or replace promptly all defects or defective equipment revealed by or noted during tests at no additional cost to the Owner.

3.02 DELIVERY, STORAGE AND HANDLING

A. All equipment shall be factory assembled, crated or shrink wrapped, and delivered to protect against damage during shipment as practical to suit shipment and installation requirements.

B. All exposed flanges shall be covered and sealed with shrink-wrap to prevent the entrance of moisture. Finished iron or steel surfaces not painted shall be properly protected with factory applied corrosion inhibiting coating.

C. All equipment delivered to the site shall be stored as specified in accordance with the equipment manufacturer’s instructions.

3.03 INSTALLATION

A. The equipment shall be installed in strict conformance with equipment manufacturer's instructions. Equipment shall be shipped in the minimum practical number of pieces for field installation. The equipment manufacturer shall provide the recommended limits of equipment disassembly for installation.

B. The equipment manufacturer shall provide factory trained personnel to supervise installation, adjustment, field testing, and initial operation of all components. The screw presses shall be aligned, connected, and installed at the locations shown and in accordance with the equipment manufacturer's recommendations.

C. A service technician employed by the equipment manufacturer shall be on site for a minimum of ten (10) consecutive days to execute the installation requirements.

3.04 FIELD TESTING

A. Comply with the requirements specified in Section 01 91 00 and as specified herein.

B. Field testing will not be conducted without an accepted procedure with no exceptions noted, calibration certificates for all testing equipment, and a completed and signed pretesting check list.

C. After installation of equipment, and after inspection, operation, testing and adjustment have been completed by the equipment manufacturer's field service technician, conduct a dry running test and an acceptance test for each unit in presence of the Owner or Owner Representative to determine its ability to deliver its rated capacity under specified conditions.

D. Functional Testing:
   1. Make all necessary adjustments and settings to the drive mechanism and tripping device at the time of the test to demonstrate that the equipment will stop at the appropriate trip setting.
   2. Perform a functional test on each screw press to demonstrate the correct alignment, smooth operation, freedom from vibration, excessive noise and overheating of the moving parts and bearings.
   3. Perform a functional test on each screw press to demonstrate the correct operating and shutdown sequence and alarms.
   4. Perform a functional test on each screw press to demonstrate the ability of the equipment to successfully operate without vibration or jamming.
   5. All defects recorded during the above functional tests and all defects and failures occurring within the first year of operation shall be corrected at no additional cost to the Owner.
   6. A service technician employed by the equipment manufacturer shall be on site for a minimum of three (3) consecutive days with a total of one (1) trip to execute the Functional Testing requirements.
   7. During this period, the presses will be optimized by the supplier, including identifying optimum polymer selection and dose.

E. Performance Testing (Acceptance Testing):

1. Field performance testing will occur at such time as the installation work is complete, functional testing has been completed, equipment is available for operations, and equipment manufacturer has test operated equipment sufficiently to establish operating conditions conducive to performance testing
2. A performance testing plan must be sent by equipment manufacturer and approved by engineer no later than thirty (30) days prior to performance testing. During the acceptance testing, the equipment manufacturer, with the assistance of the Owner's trained personnel, shall startup and operate the equipment; for the purpose of demonstrating conformance to the Guaranteed Performance Requirements specified herein. Performance test shall be a minimum of 8 hours in duration of continuous dewatering for each press. Samples shall be pulled hourly and should include no less than seven (7) samples per press for each of the following: Inlet Solids TS%, Discharge Cake TS%, Filtrate Capture %. Presses may be ran simultaneously during the performance test. The performance test shall be run to determine the actual system operating conditions and verify that the systems (each press) meet the Guaranteed Performance Requirements of this Specification. Samples from each press shall be averaged to measure overall system performance. Feed conditions shall be adjusted during the performance testing to assess performance across a range of conditions and up to the rated capacity specified herein.
3. In the case of non-acceptable performance, the equipment manufacturer shall have 30 days from the initial performance test in which to perform, at the equipment manufacturer's sole expense, all equipment modifications to meet the Guaranteed Performance Requirements and request a retest performance testing. If the modified equipment continues to not meet the Guaranteed Performance Requirements, the equipment manufacturer shall have an additional 30 days from the date of retest in which to perform, at the equipment manufacturer's sole expense, all equipment modifications to meet the Guaranteed Performance Requirements. In no case shall the total retesting duration exceed 60 days.
4. In the event the Guaranteed Performance Requirements are not met by the second retest, the following penalties will be imposed. Penalties are additive:
    a. Cake Solids:
        1) 15.00% – 15.99% TS: 25% Contract Value
        2) < 14.99% TS: 50% Contract Value
    b. Filtrate:
        1) 92.0% - 92.9%: 5% Contract Value
        2) 91.0% - 91.9%: 10% Contract Value
        3) 90.0% - 91.9%: 15% Contract Value
        4) <89.9%: 25% Contract Value
    c. Polymer Consumption:
        1) 45.1 – 47.0 lbs. active / dt – 5% Contract Value
        2) 47.1 – 49.9 lbs. active / dt – 10% Contract Value
        3) >50.0 lbs. active / dt – 15% Contract Value
    d. Throughput:
        1) 875 – 899 lb. dry per press – 5% Contract Value
        2) 850 – 875 lb. dry per press – 10% Contract Value
        3) < 849 lb. dry per press – 25% Contract Value

5. In the event the Guaranteed Performance Requirements are not met by the second retest, liquidated damages will be assessed based on a 20 year life cycle. Costs will be calculated based on missed performance and passed to the equipment manufacturer.
6. In the event the Guaranteed Performance Requirements are not met by the second retest, the equipment manufacturer shall fully replace with an equivalent system at no additional cost to the owner.
7. Proposed test procedures shall be developed and submitted by the equipment manufacturer and approved by the Engineer. A qualified representative of the equipment manufacturer shall be responsible for operating all equipment during the testing period.
8. The Owner will provide all sludge feed, water, electrical power, and sludge disposal necessary to conduct the performance testing, at no cost to the equipment manufacturer.
9. The Owner will provide existing polymer for performance testing. Should the equipment manufacturer require an alternate polymer, the equipment manufacturer shall provide polymer for performance testing.
10. All sampling shall be as directed by the equipment manufacturer to confirm performance. Equipment manufacturer shall be responsible for sampling and lab testing using an independent laboratory acceptable to the Owner and in conformance with the applicable portions of the most recent edition of the Standard Methods and provide a summary report with the results no more than 7 calendar days after successful completion of the performance testing. Owner may elect to take split samples to conduct independent analyses.
11. All defects recorded during the above field tests and all defects and failures occurring within the first year of operation shall be corrected at no additional cost to the Owner.
12. A service technician employed by the Equipment Manufacturer shall be on site for a minimum of two (2) consecutive days with a total of one (1) trip at the onset of Performance Testing, in addition to time required to optimize system operation prior to starting the performance testing on each press.

3.05 TRAINING

A. Training shall conform to Section 01 79 00.

B. A minimum of five (5) consecutive days training shall be provided with a total of two (2) trips.

C. Upon completion of the training activities, the Manufacturer shall provide an executed Instruction Certification Form 43 05 11-B.

D. The Supplier's representative shall provide one additional (4-hour) day on-site as part of a separate trip at the time of start-up to provide startup support and furnish additional training of the Owner's personnel in the operation and maintenance of the equipment.

3.06 WARRANTY

A. The Manufacturer shall furnish a full warranty for each equipment provided for a period of 2 years following successful completion of performance testing of the specific equipment. The warranty shall include one (1) inspection per year by a service technician employed by the equipment manufacturer during the 2 year warranty period. Each trip shall be 2 days in duration and shall occur during the final month of each warranty year period.

B. Submit warranty inspection results in written reports signed by factory authorized representatives of the equipment manufacturer.

END OF SECTION