9) Define recommended torquing, mounting, calibrating, and aligning procedures and settings, as appropriate.
10) Describe recommended procedures to check and test equipment following corrective maintenance.

c. Equipment Troubleshooting:
1) Define recommended systematic troubleshooting procedures.
2) Provide component-specific troubleshooting checklists.
3) Describe applicable equipment testing and diagnostic procedures to facilitate troubleshooting.
4) Describe common corrective maintenance procedures with "hands on" demonstrations.

4. Instrumentation/Controls Maintenance Training:
a. Equipment Overview: As described above.
b. Preventative Maintenance and Troubleshooting: Per Section 40 61 26, Process Control System Training. CONSTRUCTION CONTRACT ADMINISTRATOR may grant waiver(s) to allow all training for a given system to be at the Site.

1.5 TRAINING AIDS

A. Supplier's instructor shall incorporate training aids as appropriate to assist in the instruction. Provide text and figure handouts. Other appropriate training aids include:
1. Audio-Visual aids, such as videos, PowerPoint presentations, overhead transparencies, posters, blueprints, diagrams, catalog sheets.
2. Equipment cutaways and samples, such spare parts and damaged equipment.
3. Tools, such as repair tools, customized tools, measuring and calibrating instruments.

B. Handouts:
1. Supplier's instructor shall utilize descriptive class handouts during training. Customized handouts developed especially for training at the Site are encouraged.
2. Photocopied handouts shall be good quality and completely legible.
3. Handouts should accompany the instruction with frequent reference made to handouts.
4. Provide at least fifteen copies of handouts per training session.

C. Audio-visual Equipment: Supplier shall provide audio-visual equipment required for training sessions. If it is available at the Site, OWNER may make available OWNER's audio-visual equipment; however, do not count on OWNER providing audio-visual equipment. Audio-visual equipment that Supplier shall provide, as required, includes:
1. Laptop computer, presentation software, and PowerPoint projector.
2. As required, extension cords and spare bulb for projector.

3. As required, projection screen, DVD player, television monitor, and any other equipment that may be needed to complete training sessions.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION

3.1 TRAINING DELIVERY

A. General:
   1. Instructors shall be fully prepared for the training sessions. Training delivery shall be communicative, clear, and proceed according to lesson plan accepted by CONSTRUCTION CONTRACT ADMINISTRATOR, with lesson content appropriate for trainees. If OWNER or CONSTRUCTION CONTRACT ADMINISTRATOR deems that training delivery does not to conform to requirements of Specifications, training shall be postponed, rescheduled, and re-performed in acceptable manner at no additional cost to OWNER.
   2. Trainee Sign-in Sheets: In format acceptable to OWNER, provide sign-in sheet for trainees for each session. Sign-in sheets shall include the Project name, product or system for which training was provided, and type of training (e.g., operations, mechanical maintenance, instrumentation/controls maintenance, or other), and name of each trainee. Upon completion of training, provide copy of each sign-in sheet to OWNER's training coordinator.

B. "Hands-on" Demonstrations:
   1. Supplier's instructor shall present "hands-on" demonstrations of operations and maintenance of equipment for each training session, per lesson plan accepted by CONSTRUCTION CONTRACT ADMINISTRATOR.
   2. CONTRACTOR and Supplier shall all provide tools necessary for demonstrations.

+ + END OF SECTION + +

SECTION 02 41 00

DEMOLITION

PART 1 – GENERAL

1.1 DESCRIPTION

A. Scope:
   1. CONTRACTOR shall provide all labor, materials, equipment, and incidentals as shown, specified and required for demolition, removal, and disposal Work.
   2. The Work under this Section includes, but is not necessarily limited to:
      a. Demolition and removal of existing materials and equipment as shown or indicated in the Contract Documents. The Work includes demolition of structural concrete, walls, structural steel, metals, roofs, attachments, appurtenances, piping, electrical and mechanical systems and equipment, and similar existing facilities.
   3. Demolitions and removals specified under other Sections shall comply with requirements of this Section.
   4. Perform demolition Work within areas shown or indicated.
   5. Pay all costs associated with transporting and, as applicable, disposing of materials and equipment resulting from demolition.

B. Coordination:
   1. Comply with Section 01 14 16, Coordination with Owner's Operations.
   2. Review procedures under this and other Sections and coordinate the Work that will be performed with or before demolition and removals.

1.2 QUALITY ASSURANCE

A. Qualifications:
   1. Electrical Removals: Entity and personnel performing electrical removals shall be electrician legally qualified to perform electrical construction and electrical work in the jurisdiction where the Site is located.
   2. Plumbing Removals: Entity and personnel performing plumbing removals shall be plumber legally qualified to perform plumbing construction and plumbing work in the jurisdiction where the Site is located.

B. Regulatory Requirements:
   1. Demolition, removal, and disposal Work shall be in accordance with 29 CFR 1926.850 through 29 CFR 1926.860 (Subpart T - Demolition), and all other Laws and Regulations.

2. Comply with requirements of authorities having jurisdiction.

1.3 SUBMITTALS

A. Informational Submittals: Submit the following:
   1. Procedure Submittals:
      a. Demolition and Removal Plan: Not less than ten days prior to starting demolition Work, submit acceptable plan for demolition and removal Work, including:
         1) Plan for coordinating shut-offs, capping, temporary services, and continuing utility services.
         2) Other proposed procedures as applicable.
         3) Equipment proposed for use in demolition operations.
         4) Recycling/disposal facility(ies) proposed, including facility owner, facility name, location, and processes. Include copy of appropriate permits and licenses, and compliance status.
         5) Planned demolition operating sequences.
         6) Detailed schedule of demolition Work in accordance with the accepted Process Schedule.
   2. Notification of Intended Demolition Start: Submit in accordance with Paragraph 3.1.A of this Section.
   3. Qualifications Statements:
      a. Name and qualifications of entity performing electrical removals, including copy of licenses required by authorities having jurisdiction.
      b. Name and qualifications of entity performing plumbing removals, including copy of licenses required by authorities having jurisdiction.

PART 2 – PRODUCTS (NOT USED)

PART 3 – EXECUTION

3.1 PREPARATION

A. Notification:
   1. At least 48 hours prior to commencing demolition or removal, notify ENGINEER in writing of planned start of demolition Work. Do not start removals without permission of ENGINEER.
   2. CONTRACTOR shall coordinate with ENGINEER and OWNER so that the ENGINEER is on site when the tunnel and trough areas are demolished.

B. Protection of Surrounding Areas and Facilities:
   1. Perform demolition and removal Work in manner that prevents damage and injury to property, structures, occupants, the public, and facilities. Do not

interfere with use of, and free and safe access to and from, structures and properties.

2. Closing or obstructing of roads, drives, sidewalks, and passageways adjacent to the Work is not allowed unless indicated otherwise in the Contract Documents. Conduct the Work with minimum interference to vehicular and pedestrian traffic.
3. Provide temporary barriers, lighting, sidewalk sheds, and other necessary protection.
4. Repair damage to facilities that are to remain.

C. Existing Utilities: In addition to requirements of the General Conditions, Supplementary Conditions, and Division 01 Specifications, do the following:
   1. Should uncharted or incorrectly charted Underground Facilities be encountered, CONTRACTOR responsibilities shall be in accordance with the General Conditions as may be modified by the Supplementary Conditions. Cooperate with utility owners in keeping adjacent services and facilities in operation.
   2. Water Piping: Before proceeding with demolition, locate and cap all potable and non-potable waterlines and service laterals serving the building or structure being demolished.
   3. Other Utilities: Before proceeding with demolition, locate and cap as required all other utilities, such as fuel and gas; heating, ventilating, and air conditioning; electric; and communications; and service laterals serving the building or structure being demolished.
   4. Shutdown of utility services shall be coordinated by CONTRACTOR, assisted by OWNER as required relative to contacting utility owners.

3.2 DEMOLITION – GENERAL

A. Locate construction equipment used for demolition Work and remove demolished materials and equipment to avoid imposing excessive loading on supporting and adjacent walls, floors, framing, facilities, and Underground Facilities.

B. Pollution Controls:
   1. Use water sprinkling, temporary enclosures, and other suitable methods to limit emissions of dust and dirt to lowest practical level. Comply with Section 01 57 05, Temporary Controls, and Laws and Regulations.
   2. Do not use water when water may create hazardous or objectionable conditions such as icing, flooding, or pollution.
   3. Clean adjacent structures, facilities, properties, and improvements of dust, dirt, and debris caused by demolition Work, in accordance with the General Conditions and Section 01 74 05, Cleaning.

C. Salvage and Ownership:

1. Refer to Section 01 11 13, Summary of Work, for requirements on salvage, ownership, and handling of equipment and materials removed during demolition and removal Work.
2. Materials and equipment to remain OWNER's property shall be carefully removed and appropriately handled by CONTRACTOR to avoid damage and invalidation of warranties in effect, and shall be cleaned and stored at the Site (or other site specified in the Contract Documents) at place designated by ENGINEER or OWNER.

D. Finishing of Surfaces Exposed by Removals: Unless otherwise shown or indicated in the Contract Documents, surfaces of walls, floors, ceilings, and other areas exposed by removals, and that will remain as finished surfaces, shall be repaired and re-finished with materials that match existing adjacent surface, or as otherwise approved by ENGINEER.

3.3 STRUCTURAL REMOVALS

A. Remove structures to lines and grades shown or indicated, unless otherwise directed by ENGINEER. Where limits are not shown or indicated, limits shall be four inches outside item to be installed. Removals beyond limits shown or indicated shall be at CONTRACTOR's expense and such excess removals shall be reconstructed to satisfaction of ENGINEER without additional cost to OWNER.

B. Recycling and Reuse of Demolition Materials:
1. All concrete, brick, tile, masonry, roofing materials, reinforcing steel, structural metals, miscellaneous metals, plaster, wire mesh, and other items contained in or upon building or structure to be demolished shall be removed, transported, and disposed of away from the Site, unless otherwise approved by ENGINEER.
2. Do not use demolished materials as fill or backfill adjacent to structures, in pipeline trenches, or as subbase under structures or pavement.

C. After removing concrete and masonry walls or portions thereof, slabs, and similar construction that ties in to the Work or to existing construction, neatly repair the junction point to leave exposed only finished edges and finished surfaces.

D. Where parts of existing structures are to remain in service following demolition, remove the portions shown or indicated for removal, repair damage, and leave the building or structure in proper condition for the intended use.
1. Remove concrete and masonry to the lines shown or indicated by sawing, drilling, chipping, and other suitable methods. Leave the resulting surfaces true and even, with sharp, straight corners that will result in neat joints with new construction and be satisfactory for the purpose intended.
2. Do not damage reinforcing bars beyond the area of concrete and masonry removal. Do not saw-cut beyond the area to be removed.

3. Reinforcing bars that are exposed at surfaces of removed concrete and masonry that will not be covered with new concrete or masonry shall be removed to 1.5 inches below the final surface. Repair the resulting hole, with repair mortar for concrete and grout for masonry, to be flush with the surface.
4. Where existing reinforcing bars are shown or indicated to extend into new construction, remove existing concrete so that reinforcing bars are clean and undamaged.

E. Where equipment or material anchored to concrete or masonry are removed and anchors are not to be re-used, remove the anchors to not less than 1.5 inches beneath surface of concrete or masonry member. Repair the resulting hole, using repair mortar for concrete and grout for masonry, to be flush with the surface. Alternately, when the anchor is stainless steel, the anchor may be cut flush with the surface of the concrete or masonry, when so approved by ENGINEER.

E. Jambs, sills and heads of windows, passageways, doors, or other openings (as applicable) cut-in to the Work or to existing construction shall be dressed with masonry, concrete, or metal to provide smooth, finished appearance.

F. Where anchoring materials, including bolts, nuts, hangers, welds, and reinforcing steel, are required to attach the Work to existing construction, provide such materials under this Section, unless specified elsewhere in the Contract Documents.

3.4 MECHANICAL REMOVALS

A. Mechanical demolition and removal Work includes dismantling and removing existing piping, ductwork, pumps, equipment, tanks, and appurtenances as shown, indicated, and required for completion of the Work. Mechanical removals include cutting and capping as required, except that cutting of existing piping and ductwork to make connections is included under Section 01 14 16, Coordination with Owner's Operations; Section 01 73 29, Cutting and Patching; and applicable Sections of Division 40, Process Integration.

B. Demolition and Removals of Piping, Ductwork, and Similar Items:
1. Purge piping and tanks (as applicable) of chemicals or fuel (as applicable) and make safe for removal and capping. Remove to the extent shown or indicated existing process, water, waste and vent, chemical, gas, fuel, and other piping. Remove piping to the nearest solid piping support, and provide caps on ends of remaining piping. Where piping to be demolished passes through existing walls to remain, cut off and cap pipe on each side of the wall.
2. Caps, Closures, Blind Flanges, and Plugs:
   a. Provide closure pieces, such as blind flanges and caps, where shown or required to complete the Work.

b. Where used in this Section, the term "cap" means the appropriate type closure for the piping or ductwork being closed, including caps, blind flanges, and other closures.
c. Caps shall be compatible with the piping or ductwork to which the cap is attached, fluid-tight and gastight, and appropriate for the fluid or gas conveyed in the pipe or duct.
d. Unless otherwise shown or indicated, caps shall be mechanically fastened, fused, or welded to pipe or duct. Plug piping with means other than specified in this Section only when so shown or indicated in the Contractor Documents or when allowed by ENGINEER.

3. When Underground Facilities are altered or removed, properly cut and cap piping left in place, unless otherwise shown or indicated.
4. Remove waste and vent piping, and ductwork to extent shown and cap as required. Where demolished vent piping, stacks, and ductwork passes through existing roofing, patch the roof with the same or similar materials. Completed patch shall be watertight and comply with roofing manufacturer's recommendations.
5. Modifications to potable water piping and other plumbing and heating system work shall comply with Laws and Regulations. All portions of potable water system that have been modified or opened shall be hydrostatically tested and disinfected in accordance with the Contract Documents, and Laws and Regulations. Hydrostatically test other, normally-pressurized, plumbing piping and heating piping.

C. Equipment Demolition and Removals:
1. To the extent shown or indicated, remove existing process equipment; pumps; storage tanks; hoisting and conveying equipment; heating, ventilating, and air conditioning equipment; generators; and other equipment.
2. Where required, disassemble equipment to avoid imposing excessive loading on supporting walls, floors, framing, facilities, and Underground Facilities. Disassemble equipment as required for access through and egress from building or structure. Disassembly shall comply with Laws and Regulations. Provide required means to remove equipment from building or structure.
3. Remove control panels, operator stations, and instruments associated with equipment being removed, unless shown or indicated otherwise.
4. Remove fuel appurtenances as applicable, including fuel storage tanks. Dispose of tank contents in accordance with Laws and Regulations.
5. Remove equipment supports as applicable, anchorages, base, grout, and piping. Remove anchorage systems in accordance with the "Structural Removals" Article in this Section. Remove small-diameter piping back to header unless otherwise indicated.
6. Remove access platforms, ladders, and stairs related to equipment being removed, unless otherwise shown or indicated.

3.5 ELECTRICAL REMOVALS

A. Electrical demolition Work includes removing existing transformers, distribution switchboards, control panels, motors, starters, conduit and raceways, cabling, poles and overhead cabling, panelboards, lighting fixtures, switches, and miscellaneous electrical equipment, as shown, specified, or required.

B. Remove existing electrical equipment and fixtures to avoid damaging systems to remain, to keep existing systems in operation, and to maintain integrity of grounding systems.

C. Remove or modify motor control centers and switchgear as shown or indicated. Modified openings shall be cut square and dressed smooth to dimensions required for installation of equipment.

D. Disconnect and remove motors, control panels, and other electrical gear where shown or indicated. Motors, microprocessors and electronics, other electrical gear to be reused shall be stored in accordance with Section 01 66 00, Product Storage and Handling Requirements.

E. Cables in conduits to be removed shall be removed back to the power source or control panel, unless otherwise shown or indicated. Verify the function of each cable before disconnecting and removing.

F. Conduits, raceways, and cabling shall be removed where shown or indicated. Abandoned conduits concealed in floor, ceiling slabs, or in walls shall be cut flush with the slab or wall (as applicable) at point of entrance, suitably capped, and the area repaired in a flush, smooth manner acceptable to ENGINEER. Exposed conduits, junction boxes, other electrical appurtenances, and their supports shall be disassembled and removed. Repair all areas of the Work to prevent rusting on exposed surfaces.

G. Conduits in Underground Facilities not scheduled for reuse shall be suitably capped watertight where each enters building or structure to remain.

H. Where shown or indicated, remove direct burial cable. Openings in buildings for entrance of direct burial cable shall be patched with repair mortar or other material approved by ENGINEER for this purpose, and made watertight.

I. Existing poles and overhead cables shall be removed or abandoned as shown and specified. Existing substation(s) and poles owned by electric utility will be removed by the electric utility. Completely remove from the Site poles not owned by electric utility and shown or indicated for removal. Make necessary arrangements with electric utility for removal of utility company's transformers and metering equipment after new electrical system has been installed and energized.

J. Lighting fixtures, wall switches, receptacles, starters, and other miscellaneous electrical equipment, not designated as remaining as OWNER's property, shall be removed and properly disposed off-Site as required.

3.6 DISPOSAL OF DEMOLITION DEBRIS

A. Remove from the Site all debris, waste, rubbish, and material resulting from demolition operations and equipment used in demolition Work. Comply with the General Conditions, Supplementary Conditions, and Section 01 74 05, Cleaning.

B. Transportation and Disposal:
   1. Non-hazardous Material: Properly transport and dispose of non-hazardous demolition debris at appropriate landfill or other suitable location, in accordance with Laws and Regulations. Non-hazardous material does not contain Asbestos, PCBs, Petroleum, Hazardous Waste, Radioactive Material, or other material designated as hazardous in Laws and Regulations.
   2. Hazardous Material: When handling and disposal of hazardous materials is included in the Work, properly transport and dispose of hazardous materials in accordance with the Contract Documents and Laws and Regulations.

C. Submit to ENGINEER information required in this Section on proposed facility(ies) where demolition material will be recycled. Upon request, ENGINEER or OWNER, shall be allowed to visit recycling facility(ies) to verify adequacy and compliance status. During such visits, recycling facility operator shall cooperate and assist ENGINEER and OWNER.

+ + END OF SECTION + +

SECTION 03 00 05

CONCRETE

PART 1 – GENERAL

1.1 DESCRIPTION

A. Scope:
   1. CONTRACTOR shall provide all labor, materials, equipment, and incidentals as shown, specified, and required to furnish and install concrete, reinforcing, and related materials.
   2. The Work includes:
      a. Providing concrete consisting of portland cement, fine and coarse aggregates, water, and approved admixtures; combined, mixed, transported, placed, finished, and cured.
      b. Fabricating and placing reinforcing, including ties and supports.
      c. Design, erection, and removal of formwork.
      d. Building into the concrete all sleeves, frames, anchorage devices, inserts, and other items required to be embedded in concrete.
      e. Providing openings in concrete as required to accommodate Work under this and other Sections.

B. Coordination:
   1. Review installation procedures under other Sections and coordinate installation of items to be installed in the concrete Work.

C. Classifications of Concrete:
   1. Class "A" concrete shall be steel-reinforced and includes all concrete unless otherwise shown or indicated.

B. Related Sections:
   1. Section 05 05 33, Anchor Systems.

1.2 REFERENCES

A. Standards referenced in this Section are:
   1. ACI 224R, Control of Cracking in Concrete Structures.
   2. ACI 301, Specifications for Structural Concrete for Buildings.
   3. ACI 304R, Guide for Measuring, Mixing, Transporting and Placing Concrete.
   4. ACI 305R, Specification for Hot Weather Concreting.
   5. ACI 306R, Cold Weather Concreting.
   6. ACI 309R, Guide for Consolidation of Concrete.

7. ACI 318, Building Code Requirements for Structural Concrete and Commentary.
8. ACI 347, Guide to Formwork for Concrete.
9. ACI SP-66, ACI Detailing Manual.
10. ASTM A82/A82M, Specification for Steel Wire, Plain, for Concrete Reinforcement.
11. ASTM A185/A185M, Specification for Steel Welded Wire Reinforcement, Plain, for Concrete.
12. ASTM A615/A615M, Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement.
13. ASTM C31/C31M, Practice for Making and Curing Concrete Test Specimens in the Field.
14. ASTM C33/C33M, Specification for Concrete Aggregates.
15. ASTM C39/C39M, Test Method for Compressive Strength of Cylindrical Concrete Specimens.
16. ASTM C42/C42M, Test Method for Obtaining and Testing Drilled Cores and Sawed Beams of Concrete.
16. ASTM C94/C94M, Specification for Ready-Mixed Concrete.
17. ASTM C138/C138M, Test Method for Density (Unit Weight), Yield, and Air Content (Gravimetric) of Concrete.
18. ASTM C143/C143M, Test Method for Slump of Hydraulic-Cement Concrete.
19. ASTM C150/C150M, Specification for Portland Cement.
20. ASTM C172, Practice for Sampling Freshly Mixed Concrete.
21. ASTM C231, Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method.
22. ASTM C260, Specification for Air-Entraining Admixtures for Concrete.
23. ASTM C309, Specification for Liquid Membrane-Forming Compounds for Curing Concrete.
24. ASTM C494/C494M, Specification for Chemical Admixtures for Concrete.
25. ASTM C579, Methods for Compressive Strength of Chemical-Resistant Mortars, Grouts, Monolithic Surfacings, and Polymer Concretes.
26. ASTM C1064/C1064M, Standard Test Method for Temperature of Freshly Mixed Hydraulic-Cement Concrete.
27. ASTM D1752, Specification for Preformed Sponge Rubber Cork and Recycled PVC Expansion Joint Fillers for Concrete Paving and Structural Construction.
28. CRD-C 572, U. S. Army Corps of Engineers Specification for Polyvinylchloride Waterstops.
29. CRSI 1MSP, Manual of Standard Practice.

1.3 QUALITY ASSURANCE

A. Laboratory Trial Batch:
   1. Employ independent testing laboratory experienced in design and testing of concrete materials and mixes to perform material evaluation tests and to design concrete mixes.

2. Each concrete mix design specified shall be verified by laboratory trial batch, unless indicated otherwise.
3. Perform the following testing on each trial batch:
    a. Aggregate gradation for fine and coarse aggregates.
    b. Slump.
    c. Air content.
    d. Compressive strength based on three cylinders each tested at seven days and at 28 days.
4. Submit for each trial batch the following information:
    a. Project identification name and number (if applicable).
    b. Date of test report.
    c. Complete identification of aggregate source of supply.
    d. Tests of aggregates for compliance with the Contract Documents.
    e. Scale weight of each aggregate.
    f. Absorbed water in each aggregate.
    g. Brand, type, and composition of cementitious materials.
    h. Brand, type, and amount of each admixture.
    i. Amounts of water used in trial mixes.
    j. Proportions of each material per cubic yard.
    k. Gross weight and yield per cubic yard of trial mixtures.
    l. Measured slump.
    m. Measured air content.
    n. Compressive strength developed at seven days and 28 days, from not less than three test cylinders cast for each seven day and 28-day test, and for each design mix.

1.4 SUBMITTALS

A. Action Submittals: Submit the following:
    1. Shop Drawings:
        a. List of concrete materials and concrete mix designs proposed for use. Include results of tests performed to qualify the materials and to establish the mix designs. Do not start laboratory trial batch testing until this submittal is approved by ENGINEER.
        b. Laboratory Trial Batch Reports: Submit laboratory test reports for concrete cylinders, materials, and mix design tests.
        c. Concrete placement drawings showing the location and type of all joints. For joints that require waterstops, submit layout of locations showing waterstop details. Indicate waterstop type, waterstop joint conditions, and details on how joint conditions will be handled.
        d. Drawings for fabricating, bending, and placing concrete reinforcing. Comply with ACI SP-66. For walls and masonry construction, provide elevations to a minimum scale of 1/4-inch to one foot. Show bar schedules, stirrup spacing, adhesive dowels, splice lengths, diagrams of bent bars, arrangements, and assemblies, as required for fabricating and

placing concrete reinforcing.

2. Product Data:
   a. Manufacturer's specifications with application and installation instructions for proprietary materials and items, including admixtures, waterstops, non-shrink grout and bonding agents.
3. Samples:
   a. Samples: Submit samples of materials as specified and as otherwise requested by ENGINEER, including names, sources, and descriptions.

B. Informational Submittals: Submit the following:
   1. Delivery Tickets: Copies of all delivery tickets for each load of concrete delivered to or mixed at the Site. Each delivery tickets shall contain the information in accordance with ASTM C94/C94M along with project identification name and number (if any), date, mix type, mix time, quantity and amount of water introduced.

1.5 PRODUCT DELIVERY, STORAGE AND HANDLING

A. Transportation, Delivery, and Handling:
   1. Deliver concrete reinforcing products to Site bundled, tagged, and marked. Use metal tags indicating bar size, lengths, and other information corresponding to markings on approved Shop Drawings.
   2. Materials used for concrete shall be clean and free from foreign matter during transportation and handling, and kept separate until measured and placed into concrete mixer.
   3. Implement suitable measures during hauling, piling, and handling to ensure that segregation of coarse and fine aggregate particles does not occur and grading is not affected.
   4. Deliver grout materials from manufacturers in unopened containers that bear intact manufacturer labeling.

B. Storage:
   1. Store formwork materials above ground on framework or blocking. Cover wood for forms and other accessory materials with protective, waterproof covering. Provide for adequate air circulation or ventilation under cover.
   2. Store concrete reinforcing materials to prevent damage and accumulation of dirt and excessive rust. Store on heavy wood blocking so that reinforcing does not come into contact with the ground. Space framework or blocking supports to prevent excessive deformation of stored materials.
   3. Store concrete joint materials on platforms or in enclosures or covered to prevent contact with ground and exposure to weather and direct sunlight.
   4. For storage of concrete materials, provide bins or platforms with hard, clean surfaces.

PART 2 – PRODUCTS

2.1 GENERAL

A. All cementitious materials, admixtures, curing compounds, and other industrial-produced materials used in concrete, or for curing or repairing of concrete, that can contact potable water or water that will be treated to become potable shall be listed in NSF/ANSI 61.

2.2 CONCRETE MATERIALS

A. Portland Cement: ASTM C150/C150M, Type II.

B. Aggregates: ASTM C33/C33M.
   1. Fine Aggregate: Clean, sharp, natural sand free of loam, clay, lumps, and other deleterious substances. Dune sand, bank run sand, and manufactured sand are unacceptable.
   2. Coarse Aggregate:
      a. Clean, uncoated, processed aggregate containing no clay, mud, loam, or foreign matter.
      b. Coarse aggregate shall comply with the following:
         1) Crushed stone, processed from natural rock or stone.
         2) Washed gravel, either natural or crushed. Slag, pit gravel, and bank-run gravel are not allowed.
      c. Coarse Aggregate Size: ASTM C33/C33M, Nos. 57 or 67, unless otherwise approved by ENGINEER.

C. Water: Clean, potable.

D. Admixtures:
   1. Air-Entraining Admixture: ASTM C260.
   2. Water-Reducing Admixture: ASTM C494/C494M, Type A.
   3. Water Reducing and Set-Adjusting Admixtures: ASTM C494/C494M, Types D and E.
   4. High Range Water-Reducing Admixture: ASTM C494/C494M, Type F/G.
   5. Use only admixtures that have been tested and approved in the mix designs.
   6. Do not use calcium chloride or admixtures containing chloride ions.

2.3 CONCRETE MIXTURE

A. General:
   1. Normal weight: 145 pounds per cubic foot.
   2. Use air-entraining admixture in all concrete. Provide not less than four percent, nor more than seven percent, entrained air for concrete.

B. Proportioning and Design of Class "A" Concrete Mix:
   1. Minimum compressive strength at 28 days: 4,500 psi.
   2. Maximum water-cement ratio by weight: 0.42.
   3. Minimum cement content: 564 pounds per cubic yard.

C. Slump Limits:
   1. Proportion and design mixes to result in concrete slump at point of placement of not less than one inch and not more than four inches.
   2. When using high-range water reducers, slump prior to addition of admixture shall not exceed three inches. Slump after adding admixture shall not exceed eight inches at point of placement.

D. Adjustment of Concrete Mixes:
   1. Concrete mix design adjustments may be requested by CONTRACTOR when warranted by characteristics of materials, Site conditions, weather, test results, or other, similar circumstances.
   2. Submit for ENGINEER's approval laboratory test data for adjusted concrete mix designs, including compressive strength test results.
   3. Implement adjusted mix designs only after ENGINEER's approval.
   4. Adjustments to concrete mix designs shall not result in additional costs to OWNER.

2.4 FORM MATERIALS

A. Provide form materials with sufficient stability to withstand pressure of placed concrete without bow or deflection. CONTRACTOR shall be responsible for designing the formwork system to resist all applied loads including pressures from fluid concrete and construction loads.

B. Smooth Form Surfaces: Acceptable panel-type to provide continuous, straight, smooth, as-cast surfaces in accordance with ACI 301.

C. Unexposed Concrete Surfaces: Material to suit project conditions.

D. Provide 3/4-inch chamfer at all external corners. Chamfer is not required at re-entrant corners unless otherwise shown or indicated.

E. Form Ties:
   1. Provide factory-fabricated, removable, or snap-off metal form ties, that prevent form deflection and prevent spalling of concrete surfaces upon removal. Materials used for tying forms are subject to approval of ENGINEER.
   2. Unless otherwise shown or indicated, provide ties so that portion remaining within concrete after removal of exterior parts is at least 1.5 inches from outer surface of concrete. Unless otherwise shown or indicated, provide form ties

that, upon removal, will leave a uniform, circular hole not larger than one-inch diameter in the concrete surface.

3. Ties for exterior walls, below-grade walls, and walls subject to hydrostatic pressure shall be provided with waterstops.
4. Wire ties are unacceptable.

2.5 REINFORCING MATERIALS

A. Reinforcing Bars: ASTM A615/A615M, Grade 60 deformed bars.

B. Welded Wire Fabric: ASTM A185/A185M.

C. Steel Wire: ASTM A82/A82M.

D. Provide supports for reinforcing including bolsters, chairs, spacers, and other devices for spacing, supporting, and fastening reinforcing in place.
   1. Use wire bar-type supports complying with CRSI MSP1 recommendations, except as specified in this Section. Do not use wood, brick, or other unacceptable materials.
   2. For slabs on grade, use precast concrete blocks, four inches square minimum with compressive strength equal to or greater than the surrounding concrete, or supports with sand plates or horizontal runners where base materials will not support chair legs.
   3. For all concrete surfaces where legs of supports are in contact with forms, provide supports having either hot-dip galvanized, plastic-protected, or stainless steel legs in accordance with CRSI MSP1.
   4. Provide precast concrete supports over waterproof membranes.

E. Adhesive Dowels:
   1. Dowels:
      a. Dowel reinforcing bars shall comply with ASTM A615, Grade 60.
   2. Adhesive:
      a. For requirements for adhesive, refer to Section 05 05 33, Anchor Systems.

2.6 RELATED MATERIALS

A. Waterstops:
   1. PVC Waterstops:
      a. Manufacturers: Provide products of one of the following:
         1) W.R. Meadows, Inc.
         2) Greenstreak Plastic Products Company.
         3) Or equal.
      b. Waterstops shall comply with CRD-C 572. Do not use reclaimed or scrap material.

c. Minimum Thickness: 3/8-inch.
d. Provide waterstops with minimum of seven ribs equally spaced at each end on each side with the first rib located at the edge. Each rib shall be minimum 1/8-inch in height.
e. Construction Joints: Waterstops shall be six-inch wide flat-strip type.
f. Expansion Joints: Waterstops shall be nine-inch wide centerbulb type.

2. Hydrophilic Waterstops:
   a. Products and Manufacturers: Provide one of the following:
      1) Duroseal Gasket, by BBZ USA, Inc.
      2) Adeka Ultraseal MC-2010M, by Asahi Denka Kogyo K.K.
      3) Hydrotite, by Greenstreak Plastic Products Company.
      4) Or equal.
   b. Hydrophilic waterstop materials shall be bentonite-free and shall expand by minimum of 80 percent of dry volume in the presence of water to form a watertight joint seal without damaging the concrete in which it is cast.
   c. Waterstop material shall be composed of resins and polymers that absorb water and cause a completely reversible and repeatable increase in volume.
   d. Waterstop material shall be dimensionally stable after repeated wet-dry cycles with no deterioration of swelling potential.
   e. Select material in accordance with manufacturer's recommendations for type of liquid to be contained.
   f. Maximum cross-sectional dimensions: 0.08-inch by 0.59-inch.
   g. Location of hydrophilic waterstops shall be as shown or indicated on the Drawings, or where approved by ENGINEER.
   h. Hydrophilic Sealant: Shall adhere firmly to concrete, metal, and PVC in dry or damp condition and be indefinitely elastic when cured.
      1) Products and Manufacturers: Provide one of the following:
         a) Hydrotite, by Greenstreak Plastic Products Company.
         b) Or equal.

B. Epoxy Bonding Agent:
   1. Two-component epoxy resin bonding agent.
   2. Products and Manufacturers: Provide one of the following:
      a. Sikadur 32, Hi-Mod LPL, by Sika Corporation.
      b. Eucopoxy LPL, by the Euclid Chemical Company.
      c. Or equal.

C. Epoxy-Cement Bonding Agent:
   1. Three-component blended epoxy resin-cement bonding agent.
   2. Products and Manufacturers: Provide one of the following:
      a. Sika Armatec 110 EpoCem, by Sika Corporation.
      b. Duralprep A.C., by Euclid Chemical Company.
      c. Or equal.

D. Preformed Expansion Joint Filler:
   1. Provide preformed expansion joint filler complying with ASTM D1752, Type I (sponge rubber) or Type II (cork).

E. Joint Sealant and Accessories:
   1. For joint sealants and accessories used on isolation joints, control joints, and expansion joints, refer to Section 07 92 00, Joint Sealants.

2.7 GROUT

A. Non-shrink Grout:
   1. Pre-packaged, non-metallic, cementitious grout requiring only the addition of water at the Site.
   2. Minimum 28-day Compressive Strength: 7,000 psi.
   3. Products and Manufacturers: Provide one of the following:
      a. NS Grout by Euclid Chemical Company.
      b. Construction Grout, by Master Builders, Inc.
      c. FSP Construction Grout, by Five Star Products, Inc.
      d. Or equal.

B. Epoxy Grout:
   1. Pre-packaged, non-shrink, non-metallic, 100 percent solids, solvent-free, moisture-insensitive, three-component epoxy grouting system.
   2. Minimum Seven-day Compressive Strength: 14,000 psi, when tested in accordance with ASTM C579.
   3. Products and Manufacturers: Provide one of the following:
      a. Euco High Strength Grout, by Euclid Chemical Company.
      b. Sikadur 42, Grout Pak, by Sika Corporation.
      c. Five Star Epoxy Grout, by Five Star Products, Inc.
      d. Or equal.

C. Grout Fill:
   1. Grout mix shall consist of cement, fine and coarse aggregates, water, and admixtures complying with requirements specified in this Section for similar materials in concrete.
   2. Proportion and mix grout fill as follows:
      a. Minimum Cement Content: 564 pounds per cubic yard.
      b. Maximum Water-Cement Ratio: 0.45.
      c. Maximum Coarse Aggregate size: 1/2-inch, unless otherwise indicated.
      d. Minimum 28-day Compressive Strength: 4,000 psi.

PART 3 – EXECUTION

3.1 INSPECTION

A. CONTRACTOR shall examine the substrate and the conditions under which the Work will be performed and notify ENGINEER in writing of unsatisfactory conditions. Do not proceed with the Work until unsatisfactory conditions are corrected.

3.2 FORMWORK

A. Construct formwork in accordance with ACI 347 such that concrete members and structures are of correct size, shape, alignment, elevation, and position.

B. Provide openings in formwork to accommodate the Work of other trades. Accurately place and securely support items required to be built into formwork.

C. Clean and adjust forms prior to placing concrete. Apply form release agents or wet forms as required. Re-tighten forms during and after concrete placing, when required, to eliminate cement paste leaks.

D. Removing Formwork:
   1. Comply with ACI 301 and ACI 347, except as otherwise indicated in the Contract Documents.
   2. Do not remove formwork and shoring until supported concrete members have acquired minimum of 90 percent of specified compressive strength. Results of suitable quality control tests of field-cured specimens may be submitted to ENGINEER for review as evidence that concrete has attained sufficient strength for removal of supporting formwork and shoring prior to removal times indicated in the Contract Documents.
   3. Removal time for formwork is subject to ENGINEER's acceptance.
   4. Repair form tie-holes following in accordance with ACI 301.

3.3 REINFORCING, JOINTS, AND EMBEDDED ITEMS

A. Comply with the applicable recommendations of Laws and Regulations and standards referenced in this Section, including CRSI MSP1, for details and methods of placing and supporting reinforcing.

B. Clean reinforcing to remove loose rust and mill scale, earth, ice, and other materials which act to reduce or destroy bond between reinforcing material and concrete.

C. Position, support, and secure reinforcing against displacement during formwork construction and concrete placing. Locate and support reinforcing by means of metal chairs, runners, bolsters, spacers, and hangers, as required.
   1. Place reinforcing to obtain minimum concrete coverages as shown on the Drawings and as required in ACI 318. Arrange, space, and securely tie bars and bar supports together with 16-gage wire to hold reinforcing accurately in

position during concrete placing. Set with ties so that twisted ends are directed away from exposed concrete surfaces.

2. Do not secure reinforcing to formwork using wire, nails or other ferrous metal. Metal supports subject to corrosion shall not be in contact with formed or exposed concrete surfaces.

D. Provide sufficient quantity of supports of strength required to carry reinforcing. Do not place reinforcing more than two inches beyond the last leg of continuous bar support. Do not use supports as bases for runways for concrete conveying equipment and similar construction loads.

E. Splices: Provide standard reinforcing splices by lapping ends, placing bars in contact, and tying tightly with wire. Comply with requirements shown or indicated for minimum lap of spliced bars, as shown on the Drawings.

F. Install welded wire fabric in lengths as long as practical, lapping adjoining sections a minimum of one full mesh.

G. Do not place concrete until reinforcing is inspected and ENGINEER indicates that conditions are acceptable for placing concrete. Concrete placed in violation of this paragraph will be rejected. Notify ENGINEER in writing at least two working days prior to proposed concrete placement.

H. Joints:
   1. Provide construction, isolation, expansion, and control joints as indicated or required. Locate construction joints so as to not impair the strength and appearance of the structure. Place isolation and control joints in slabs-on-grade to stabilize differential settlement and random cracking.
   2. In walls, locate joints at a maximum spacing of 40 feet and approximately 12 feet from corners.
   3. In foundation slabs and slabs-on-grade, locate joints at intervals of approximately 40 feet.
   4. In mats and structural slabs and beams, locate joints in compliance with ACI 224R.
   5. Locations of joints shall be in accordance with the Contract Documents and as approved by ENGINEER in the Shop Drawings.
   6. Provide waterstops in all joints where concrete construction is below grade or intended to retain liquid. Install waterstop to the higher of: at least 12 inches above grade, or 12 inches above overflow liquid level in tanks. Provide PVC waterstops, except where otherwise shown or indicated on the Drawings.
   7. Where construction joints are indicated to be roughened, intentionally roughen surfaces of previously-placed concrete to amplitude of 1/4-inch.

I. Installation of Embedded Items: Set and build into the Work anchorage devices and embedded items required for other Work that is attached to, or supported by, cast-in-

place concrete. Use setting diagrams, templates, and instructions provided under other Sections for locating and setting. Refer to Paragraph 1.1.B of this Section. Do not embed in concrete uncoated aluminum items. Where aluminum items are in contact with concrete surfaces, coat aluminum to prevent direct contact with concrete.

J. Adhesive Dowels:
   1. Adhesive dowels shall be reinforcing bar dowels set in an adhesive in a hole drilled into hardened concrete. Comply with adhesive system manufacturer's installation instructions regarding hole diameter, drilling method, embedment depth required to fully develop required tensile strength, and hole cleaning and preparation instructions. Unless more-stringent standards are required by adhesive system manufacturer, comply with the following.
   2. Drill holes to adhesive system manufacturer's recommended diameter and depth to develop required tensile strength. Holes shall not be more than 1/4-inch greater than nominal bar diameter, and hole depth shall not be less than twelve times nominal bar diameter. Hammer-drill holes. Cored holes are not allowed.
   3. Embedment depths shall be based on concrete compressive strength of 4,000 psi when embedded in existing and new concrete.
   4. Determine location of existing reinforcing steel in vicinity of proposed holes prior to drilling. Adjust location of holes to be drilled to avoid drilling through or damaging existing reinforcing bars only when approved by ENGINEER.
   5. Before setting adhesive dowel, hole shall be free of dust and debris using method recommended by adhesive system manufacturer. Hole shall be brushed, with manufacturer-approved brush and blown clean with clean, dry, oil-free compressed air to remove dust and loose particles. Hole shall be dry as defined by adhesive system manufacturer.
   6. Inject adhesive into hole through injection system mixing nozzle and necessary extension tubes, placed to bottom of hole. Withdraw discharge end as adhesive is placed, but keep end of tube immersed to prevent forming air pockets. Fill hole to depth that ensures that excess material is expelled from hole during dowel placement.
   7. Twist dowels during insertion into partially-filled hole to guarantee full wetting of bar surface with adhesive. Insert bar slowly to avoid developing air pockets.

3.4 BONDING AGENT

A. Use epoxy bonding agent for bonding of fresh concrete to concrete that has been in place for at least 60 days, and for bonding to existing concrete.

B. Use epoxy-cement bonding agent for the following:
   1. Bonding toppings and concrete fill to concrete that has been in place for at least 60 days, and for bonding to existing concrete.

2. For locations where bonding agent is required and concrete cannot be placed within open time period of epoxy bonding agent.

3.5 CONCRETE PLACING

A. Site Mixing: When Site mixing of concrete is approved by ENGINEER , use drum-type batch machine mixer, mixing not less than 1.5 minutes for one cubic yard or smaller capacity. Increase required mixing time by minimum of 15 seconds for each additional cubic yard or fraction thereof.

B. Ready-Mixed Concrete: Comply with ASTM C94/C94M.

C. Concrete Placing:
   1. Place concrete in a continuous operation within planned joints or sections in accordance with ACI 304R.
   2. Do not begin placing concrete until work of other trades affecting concrete is completed.
   3. Wet concrete and subgrade surfaces to saturated surface dry condition immediately prior to placing concrete.
   4. Deposit concrete as near its final location as practical to avoid segregation due to re-handling or flowing.
   5. Avoid separation of the concrete mixture during transportation and placing. Concrete shall not free-fall for distance greater than four feet during placing.
   6. Complete concrete placing within 90 minutes of addition of water to the dry ingredients.

D. Consolidate placed concrete in accordance with ACI 309R using mechanical vibrating equipment supplemented with hand rodding and tamping, such that concrete is worked around placing and other embedded items and into all parts of formwork. Insert and withdraw vibrators vertically at uniformly-spaced locations. Do not use vibrators to transport concrete within the formwork. Vibration of formwork or placing is not allowed.

E. Protect concrete from physical damage or reduced strength due to weather extremes during mixing, placing, and curing.
   1. In hot weather comply with ACI 305R.
   2. In cold weather comply with ACI 306R.

3.6 QUALITY OF CONCRETE WORK

A. Make concrete solid, compact, smooth, and free of laitance, cracks, and cold joints.

B. Concrete for liquid-retaining structures and concrete in contact with earth, water, or exposed directly to the elements shall be watertight.

C. Cut out and properly replace to extent directed by ENGINEER, or repair to satisfaction of ENGINEER, surfaces that contain cracks or voids, are unduly rough, or are in defective in any way. Patches or plastering are unacceptable.

D. Repair, removal and replacement of defective concrete directed by ENGINEER shall be at no additional cost to OWNER.

3.7 CURING

A. General:
   1. Protect freshly placed concrete from premature drying, excessive cold or hot temperatures, and maintain without drying at relatively constant temperature for period necessary for hydration of cement and proper hardening of concrete.
   2. Start curing after placing and finishing concrete, as soon as free moisture has disappeared from concrete surface. Keep surface continuously moist during entire curing period. Cure for a minimum of 7 days and in accordance with ACI 301 procedures. Avoid rapid drying at end of final curing period.
   3. For curing, use water that is free of impurities that could etch or discolor exposed concrete surfaces.
   4. Confine water for curing to area being cured.

B. Curing Methods: Curing methods are specified below. Curing methods to be used on each type of concrete surface are specified elsewhere in this Article.
   1. Water Curing. Cure by one of the following methods:
      a. Keep concrete surface continuously wet.
      b. Ponding or immersion.
      c. Continuous water-fog spray.
      d. Covering concrete surface with curing mats, thoroughly saturating mats with water, and keeping mats continuously wet with sprinklers or porous hoses. Place curing mats to cover concrete surfaces and edges with four-inch horizontal lap over adjacent mats; provide eight-inch lap over adjacent mats at vertical surfaces. If necessary, weigh down curing cover to maintain contact with concrete surface.
   2. Form Curing. Cure by one of the following methods:
      a. Forms shall be maintained and loosened during curing period.
      b. Immediately after forms are loosened or removed, continue with the required curing method as applicable, for remainder of curing period.
      c. Where wood forms are kept in place, apply water to keep forms wet.
   3. Moisture Retaining Cover Curing. Cure as follows:
      a. Cover concrete surfaces with the required moisture retaining cover for curing concrete, placed in widest practical width with sides and ends lapped at least three inches and sealed using waterproof tape or adhesive. Immediately repair holes or tears during curing period using cover material and waterproof tape.

C. Formed Surfaces: Use the following curing methods:
   1. Walls That Will Retain Liquid or That are Under Ground Surface:
      a. If forms are wood, form curing is allowed for entire curing period. If forms are steel, form curing is allowed for maximum of three days after which forms shall be removed so that concrete is free of the forms for remainder of the curing process.
      b. Immediately after the forms are loosened or removed, continue with water curing for remainder of curing period.
      c. When wall surface will not receive surface treatment and when allowed by ENGINEER, use of liquid curing compound is allowed. Before using liquid compound curing, use water curing or form curing for at least the first three days of curing.
   2. Formed Slab Underside and Beam Surfaces Where Will Retain Liquid:
      a. Form curing is allowed for the full curing period.
      b. Immediately after forms are loosened or removed, continue with water curing for remainder of curing period.
      c. When slab surface will not receive surface treatment and when allowed by ENGINEER, use of liquid curing compound is allowed.
   3. Vertical Joint Surfaces and Surfaces to Receive Surface Treatment:
      a. Form curing is allowed for entire curing period.
      b. Immediately after forms are loosened or removed, continue with water curing for remainder of curing period.
   4. Cure other formed surfaces using an appropriate curing method specified in the Contract Documents.

D. Unformed Surfaces: Treat with one of the following curing methods:
   1. Slabs and Mats That Will Retain Liquid or are Below Ground Surface:
      a. Water curing.
      b. Moisture-retaining cover curing when allowed by ENGINEER.
      c. When slab or mat surface will not receive surface treatment and when allowed by ENGINEER, use of liquid curing compound is allowed. Before using liquid compound curing, use water curing or form curing for at least the first three days of curing.
   2. Construction Joint Surfaces and Slab and Mat Surfaces to Receive Surface Treatment.
      a. Water curing.
      b. Moisture-retaining cover curing.
   3. Cure other formed surfaces using an appropriate curing method specified in the Contract Documents.

3.8 FINISHING

A. Slab Finish:
   1. After placing concrete slabs, do not work the surface further until ready for floating. Begin floating when surface water has disappeared or when concrete

has stiffened sufficiently. Use a wood float only. Check and level surface plane to a tolerance not exceeding 1/4-inch in ten feet when tested with a ten foot straightedge placed on the surface at not less than two different angles. Cut down high spots and fill low spots. Uniformly slope surfaces to drains. Immediately after leveling, re-float the surface to a uniform, smooth, granular texture. Slab surfaces shall receive a float finish. Provide additional trowel finishing as required in this Section.

2. After floating, begin first trowel finish operation using power-driven trowel. Begin final troweling when surface produces a ringing sound as trowel is moved over the surface.
3. Consolidate concrete surface by the final hand troweling operation. Finish shall be free of trowel marks, uniform in texture and appearance, and with a surface plane tolerance not exceeding 1/8-inch in ten feet when tested with a ten-foot straightedge. Grind smooth surface defects that would telegraph through applied floor covering system.
4. Use trowel finish for the following:
   a. Interior exposed slabs, unless otherwise shown or indicated.
   b. Apply non-slip broom finish, after troweling, to exterior concrete slab and elsewhere as shown.

B. Formed Finish:
   1. Provide smooth form concrete finish at exposed surfaces. Use largest practical form panel sizes to minimize form joints. Exposed surfaces include interior water-contacting surfaces of tanks, whether or not directly visible. All surfaces shall be considered as exposed, unless buried or covered with permanent structural or architectural material. After removing forms, patch form tie holes and defects in accordance with ACI 301. Remove fins exceeding 1/8-inch in height. Where surface will be coated or will receive further treatment, remove all fins flush with concrete surface.
   2. Provide rough form finish at all unexposed surfaces. After removing forms, patch form tie holes and defects in accordance with ACI 301. Remove fins exceeding 1/2-inch in height.

C. Grout Cleaned Finish:
   1. Provide grout cleaned finish to concrete surfaces that have received smooth form finish and where defects have been repaired, as follows:
      a. Combine one part portland cement to 1.5 parts fine sand by volume, and mix with water to consistency of thick paint. Blend standard portland cement and white portland cement, in proportions determined by trial patches, so that final color of dry grout will closely match adjacent concrete surfaces.
      b. Thoroughly wet concrete surface and apply grout uniformly by brushing or spraying immediately to wetted surfaces. Scrub surface with cork float or stone to coat surface and fill surface holes. Remove excess grout by scraping, followed by rubbing with clean burlap to remove visible grout

film. Keep grout damp during setting period by using fog spray on surface for at least 36 hours after final rubbing. Complete each area the same day the area is started, with limits of each area being natural breaks in the finished surface.

2. Use grout cleaned finish for the following:
   a. Interior exposed walls and other vertical surfaces.
   b. Exterior exposed walls and other vertical surfaces down to one foot below grade.
   c. Interior and exterior horizontal surfaces, except exterior exposed slabs and steps.
   d. Interior exposed vertical surfaces of liquid-containing structures down to one foot below normal operating liquid level.
   e. Other areas shown.

3.9 GROUT PLACING

A. Place grout as shown and indicated, and in accordance with grout manufacturer's instructions and recommendations. If grout manufacturer's instructions conflict with the Contract Documents, notify ENGINEER and do not proceed until obtaining ENGINEER's clarification.

B. Dry-packing is not allowed, unless otherwise indicated.

C. Manufacturers of proprietary grout materials shall make available upon 72 hours notice the services of qualified, full-time, factory-trained employee to aid in ensuring proper use of grout materials at the Site.

D. Placing grout shall comply with temperature and weather limitations described in Article 3.4 of this Section.

3.10 FIELD QUALITY CONTROL

A. Site Testing Services:
   1. OWNER will employ testing laboratory to perform field quality control testing for concrete. ENGINEER will direct the testing requirements.
   2. Testing laboratory will provide all labor, material, and equipment required for sampling and testing concrete, including: scale, glass tray, cones, rods, molds, air tester, thermometer, and other incidentals required.

B. Quality Control Testing During Construction:
   1. Perform sampling and testing for field quality control during concrete placing, as follows:
      a. Sampling Fresh Concrete: ASTM C172.
      b. Slump: ASTM C143/C143M; one test for each concrete load at point of discharge.

c. Concrete Temperature: ASTM C1064/C1064M; one for every two concrete loads at point of discharge, and when a change in the concrete is observed. Test each load when time from batching to placement exceeds 75 minutes.

d. Air Content: ASTM C231; one for every two concrete load at point of discharge, and when a change in the concrete is observed.

e. Unit Weight: ASTM C138/C138M; one for every two concrete loads at point of discharge, and when a change in the concrete is observed.

f. Compression Test Specimens:
   1) In accordance with ASTM C31/C31M, make one set of compression cylinders for each 50 cubic yards of concrete, or fraction thereof, of each mix design placed each day. Each set shall be four standard cylinders, unless otherwise directed by ENGINEER.
   2) Cast, store, and cure specimens in accordance with ASTM C31/C31M.

g. Compressive Strength Tests:
   1) In accordance with ASTM C39/C39M; one specimen tested at seven days, and three specimens tested at 28 days.
   2) Concrete that does not comply with strength requirements will be considered as defective Work.

h. Within 24 hours of completion of test, testing laboratory will transmit certified copy of test results to CONTRACTOR and ENGINEER.

i. When there is evidence that strength of in-place concrete does not comply with the Contract Documents, CONTRACTOR shall employ the services of concrete testing laboratory to obtain cores from hardened concrete for compressive strength determination. Cores and tests shall comply with ASTM C42/C42M and the following:
   1) Testing of Adhesive Dowels: Owner will employ testing agency to perform field quality control testing of drilled dowel installations. After adhesive system manufacturer's recommended curing period and prior to placing connecting reinforcing, proof-test for pullout ten percent of adhesive dowels installed. Adhesive dowels shall be tensioned to 60 percent of specified yield strength. Where dowels are located less than six bar diameters from edge of concrete, ENGINEER will determine tensile load required for test. If one or more dowels fail, retest all dowels installed for the Work. Dowels that fail shall be reinstalled and retested at CONTRACTOR's expense.

++ END OF SECTION ++

SECTION 03 01 30

REPAIR AND REHABILITATION OF CAST-IN-PLACE CONCRETE

PART 1 – GENERAL

1.1 DESCRIPTION

A. Scope:
   1. CONTRACTOR shall provide all labor, materials, equipment, and incidentals as shown, specified, and required to repair or rehabilitate, as required, all existing concrete shown or indicated in the Contract Documents as being repaired or rehabilitated.
   2. CONTRACTOR shall repair all damage to new concrete construction as specified in this Section except for repair Work specified in Section 03 00 05, Concrete.

B. Coordination:
   1. Review installation procedures under this and other Sections and coordinate the Work that must be installed with or before repair and rehabilitation of concrete.

C. Related Sections:
   1. Section 03 00 05, Concrete.

1.2 REFERENCES

A. Standards referenced in this Section are:
   1. ASTM C109/C109M, Test Method for Compressive Strength of Hydraulic Cement Mortars (Using 2-in. or [50-mm] Cube Specimens).
   2. ASTM C882/C882M, Test Method for Bond Strength of Epoxy-Resin Systems Used with Concrete by Slant Shear.
   3. ASTM D1042, Test Method for Linear Dimensional Changes of Plastics Under Accelerated Service Conditions.
   4. ASTM D3574, Test Methods for Flexible Cellular Materials – Slab, Bonded, and Molded Urethane Foams.
   5. ASTM G109, Test Method for Determining the Effects of Chemical Admixtures on the Corrosion of Embedded Steel Reinforcement in Concrete Exposed to Chloride Environments.
   6. NSF/ANSI 61, Drinking Water System Components – Health Effects.

1.3 SUBMITTALS

A. Action Submittals: Submit the following:

1. Product Data: Information on all products proposed for use, including manufacturer's brochures, technical data, specifications, and other applicable data.

B. Informational Submittals: Submit the following:
   1. Certificates: Certificates documenting that repair materials that will be in contact with potable water or water that will be treated to become potable are listed in NSF/ANSI 61.
   2. Manufacturer's Instructions: Manufacturer's recommended procedures for installing materials proposed for use.
   3. Special Procedure Submittals: When requested by ENGINEER, submit information on methods for supporting, during demolition and repair Work, existing structures, pipes, and other existing facilities affected by the Work.

1.4 PRODUCT DELIVERY, STORAGE AND HANDLING

A. Delivery and Handling of Materials:
   1. Conform to Section 01 65 00, Product Delivery Requirements, and this Section.
   2. Clearly mark on containers manufacturer's name and label, name or title of material, manufacturer's stock number, and date of manufacture.
   3. Handle materials carefully to prevent inclusion of foreign matter.
   4. Do not open containers or mix components until necessary preparatory Work has been completed and application Work is to start immediately.

B. Storage of Materials:
   1. Conform to Section 01 66 00, Product Storage and Handling Requirements, and this Section.
   2. Store only approved materials at the Site.

PART 2 – PRODUCTS

2.1 SYSTEM REQUIRMENTS

A. All repair and rehabilitation materials that can or will come into contact with potable water or that will be treated to become potable shall be listed in ANSI/NSF 61.

2.2 REPAIR MORTAR

A. Product Description: Repair mortar shall be prepackaged, cement-based product specifically formulated for repairing concrete surface defects.

B. Products and Manufacturers: Provide one of the following:
   1. SikaTop 122 Plus or SikaTop 123 Plus, by Sika Corporation.
   2. DuralTop Gel, DuralTop Flowable Mortar by Euclid Chemical Company.
   3. Or equal.

C. Materials:
   1. Provide a two-component, polymer-modified, Portland cement, fast-setting, trowel-grade mortar. Repair mortar shall be enhanced with penetrating corrosion inhibitor, and shall have the following properties:

Physical Property	Value	ASTM Standard
Minimum Compressive Strength at One Day	2,000 psi	C109
Minimum Compressive Strength at 28 Days	6,000 psi	C109
Minimum Bond Strength at 28 Days	1,800 psi	C882*
* Modified for use with repair mortars.		

   2. Where the least dimension of the placement in width or thickness exceeds four inches, extend repair mortar by adding aggregate as recommended by repair mortar manufacturer.
   3. Product shall be listed in NSF/ANSI 61.

2.3 EXPANSION JOINT REPAIR SYSTEM

A. System Description: Joint repair system shall consist of two components: an epoxy resin adhesive and hypalon sheeting.

B. Products and Manufacturers: Provide one of the following:
   1. Sikadur Combiflex, by Sika Corporation.
   2. Or equal.

C. Materials:
   1. Epoxy Resin Adhesive: Provide two-component epoxy resin as follows:
      a. Component "A" shall be modified epoxy resin of epichlorohydrin bisphenol-A type containing suitable viscosity control agents and pigments. Resin shall not contain butyl glycidyl ether.
      b. Component "B" shall be primarily a reaction product of selected amine blend with epoxy resin of epichlorohydrin bisphenol-A type containing suitable viscosity control agents, pigments, and accelerators.
   2. Hypalon Sheeting:
      a. Provide sheeting of hypalon rubber, perforated along bonding edge to provide mechanical key. Sheeting shall have ability to be vulcanized with hydrocarbon solvent for adhesion to an epoxy resin adhesive.
      b. Provide sheeting in 12-inch width with thickness of 40 mils.
      c. Sheeting shall be able to be lapped or seamed by heat or by anaromatic hydrosolvent strip.
      d. Provide sheeting with removable center expansion strip.
   3. Products shall be listed in NSF/ANSI 61.

2.4 CRACK INJECTION REPAIR SYSTEM

A. Non-structural Crack Repair System:
   1. Hydrophobic Polyurethane Chemical Grout:
      a. Provide hydrophobic polyurethane that forms a flexible gasket.
      b. Products and Manufacturers: Provide one of the following:
         1) SikaFix HH LV, by Sika Chemical Company.
         2) Hydro Active Flex SLV, by De Neef Construction Chemicals, Inc.
         3) Or equal.
      c. Shrinkage limit shall not exceed 4.0 percent in accordance with ASTM D1042.
      d. Minimum elongation of 250 percent in accordance with ASTM D3574.
      e. Minimum tensile strength of 150 psi in accordance with ASTM D3574.
      f. Product shall be listed in NSF/ANSI 61.
   2. Hydrophilic Acrylate-Ester Resin:
      a. Hydrophilic crack repair system shall be acrylate-ester resin that forms a flexible gasket and increase in volume by at least 50 percent when in contact with water.
      b. Products and Manufacturers: Provide one of the following:
         1) Duroseal Multigel 850, manufactured by BBZ USA, Inc.
         2) Or equal.
      c. Product shall be listed in NSF/ANSI 61.

2.5 POLYURETHANE COATING SYSTEM

A. Provide a two-component elastomeric polyurethane coating waterproofing system consisting of a high solids, fast curing base coat and aliphatic, polyurethane top coat.
   1. Polyurethane Base Coat:
      a. Products and Manufacturers: Provide one of the following:
         1) Sikalastic 720 Base
         2) Or equal
      b. Minimum tensile strength of 2500 psi in accordance with ASTM D-412.
      c. Minimum elongation of 800% in accordance with ASTM D-412.
      d. Minimum hardness of 80 Shore A in accordance with ASTM D-2240.
   2. Polyurethane Top Coat:
      a. Products and Manufacturers: Provide one of the following:
         1) Sikalastic 745 AL
         2) Or equal
      b. Minimum tensile strength of 3200 psi in accordance with ASTM D-412.
      c. Minimum elongation of 450% in accordance with ASTM D-412.
      d. Minimum hardness of 85 Shore A in accordance with ASTM D-2240.

PART 3 – EXECUTION

3.1 INSPECTION

A. Examine areas and conditions under which the repair Work is to be installed and notify ENGINEER in writing of conditions detrimental to proper and timely completion of the Work. Do not proceed with the Work until unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Surface Preparation:
   1. Initial Surface Preparation: Remove by chipping, abrasive blasting, or hydro blasting all laitance, foreign material, and unsound concrete from entire area to be repaired. Further roughen surface as specified in this Section. Where non-shrink grout or repair mortar is used, perform additional surface preparation, if any, recommended by product manufacturer.
   2. Wetting Procedure: Where repair concrete, shotcrete, or cement grout is used, and bonding agent is not required, or where repair mortar or non-shrink grout manufacturer recommends wet or saturated surface, perform the following:
      a. Continuously apply water for at least four hours to surface being repaired. Where large surface areas are to be repaired, use fog-spray nozzles, mounted on stands, in sufficient number so that entire surface to be repaired is contacted by fog spray cloud.
      b. Prevent concrete from drying until after repair is completed. Re-wet surfaces not yet repaired using water sprays at least daily; should more than four days elapse without re-wetting surfaces not yet repaired, repeat the original saturating procedure.
      c. Remove standing water in areas to be repaired before placing repair material. Provide means to remove excess water from structure.
   3. Preparation for Epoxy Bonding Agent: Where repair material manufacturer recommends use of epoxy-bonding agent, conform to recommendations of both repair material manufacturer and bonding agent manufacturer.

3.3 INSTALLATION, GENERAL

A. Construction Tolerances: Shall be as specified in Section 03 00 05, Concrete, except as specified in this Section and elsewhere in the Contract Documents.

B. Care shall be taken to fully consolidate repair material, completely filling all portions of space to be filled.

C. Bring surface being repaired into alignment with adjacent surfaces, providing uniform, even surface. Surface repaired shall match adjacent existing surfaces in texture and shall receive coatings or surface treatments, if any, provided for the existing surface adjacent to repaired surface.

D. Curing:
   1. Curing of repair mortar and non-shrink grout shall be in accordance with manufacturer's recommendations, except that minimum cure period shall be three days.
   2. Curing of other materials shall be in accordance with requirements of Section 03 00 05, Concrete.

3.4 REPAIR OF SURFACE DEFECTS

A. Surface defects are depressions in a concrete surface that do not extend all the way through the concrete. Surface defects can result from removal of an embedded item, removal of an intersecting concrete member, physical damage, or unrepaired rock pockets created during original placement.

B. Preparation: Perform the following in addition to requirements of Article 3.2 of this Section:
   1. Remove by chipping all loose, damaged concrete to sound material.
   2. Where existing reinforcing is exposed, remove concrete to minimum of one-inch around exposed bars. If existing bars are cut through, cracked, or cross sectional area is reduced by more than 25 percent from original, immediately notify ENGINEER.
   3. Score-cut perimeter of area to be repaired to minimum depth of 1/2-inch and maximum depth that will not cut existing reinforcing steel. Chip out existing concrete to the score line so that minimum thickness of repair mortar will be 1/2-inch.

C. Repair Material:
   1. Completely fill the surface defect with specified repair material, in accordance with material manufacturer's instructions and the Contract Documents.
   2. Perform, with repair mortar, repairs of surface defects in concrete normally in contact with water or soil, and interior surfaces of structures that contain water.
   3. Repair of other surface defects may be by applying repair mortar, repair concrete, shotcrete, or cement grout, as appropriate.

3.5 REPAIR OF DETERIORATED CONCRETE

A. This Article pertains to deteriorated concrete which has been damaged due to corrosion of reinforcing steel, physical damage due to abrasion, or damage due to chemical attack. Use repair mortar, as specified in this Article, for repairing deteriorated concrete. Where repaired surface will be subsequently covered with plastic liner material, coordinate finishing with requirements for installing plastic liner material.

B. Surface Preparation: In addition to requirements of Article 3.2 of this Section, perform the following surface preparation:

1. Remove loose, broken, softened, and acid-contaminated concrete by abrasive blasting and chipping to sound, uncontaminated concrete.
2. Upon completion of removal of deteriorated concrete, notify ENGINEER in writing. Allow two weeks for ENGINEER to evaluate the surface, perform testing for acid contamination if required, determine if additional concrete shall be removed, and to develop special repair details (if any) required. Should ENGINEER determine that additional concrete be removed to reach sound, uncontaminated concrete, allow another two-week period for further evaluation and testing following the additional removal.
3. Surface preparation shall conform to recommendations of repair mortar manufacturer.
4. Repair and rehabilitate isolated areas of exposed reinforcing bars in accordance with Article 3.4 of this Section. If extensive areas of reinforcing steel are uncovered after removal of deteriorated concrete, ENGINEER will determine the repair methods required.

C. Repair Mortar Placing:
   1. Conform to manufacturer's recommended procedures for mixing and placing repair mortar.
   2. After initial mixing of repair mortar, addition of water is not allowed.
   3. Minimum Thickness:
      a. Install repair mortar to not less than minimum thickness recommended by manufacturer, and not less than 1/2-inch.
      b. Where removal of deteriorated concrete results in repair thickness of less than minimum required thickness to return to original concrete surface in isolated areas totaling less than ten percent of total repair surface area, remove additional concrete to obtain at least the required minimum thickness.
      c. Where surface area with repair thickness less than minimum required thickness exceeds ten percent of total repair area, notify ENGINEER.
      d. Provide repair mortar so that minimum cover over existing reinforcing steel is two inches. Do not place repair mortar creating locally raised areas.
      e. Where transitioning to or from wall surfaces not requiring repair, do not feather-out repair mortar at transition. Instead, form the transition by saw cutting a score line to not less than minimum required repair mortar depth and chip out concrete to the saw cut line. Do not cut or otherwise damage reinforcing steel.
   4. Place repair mortar to an even, uniform plane to restore concrete member to its original surface. Out-of-plane tolerance shall be such that the gap between 12-inch long straight edge and repair mortar surface does not exceed 1/8-inch, and gap between a four-foot long straight edge and repair mortar surface shall not exceed 1/4-inch. Tolerances specified in this paragraph apply to straight edges placed in any orientation at any location.

D. Finishing:
   1. Provide smooth, steel trowel finish to repair mortar.

2. When completed, there shall be no sharp edges. Provide exterior corners, such as at penetrations, one-inch radius. Interior corners shall be square, except corners to receive plastic lining which shall be made with two-inch fillet in repair mortar.

3.6 REPAIR OF EXPANSION JOINTS

A. Surface Preparation: Remove the following from surfaces to be repaired: laitance, foreign material, and unsound concrete. Remove by chipping, abrasive blasting, or hydro blasting. Additional surface preparation, if required, shall be as recommended by expansion joint repair system manufacturer.

B. Installation: Installation shall be as recommended by expansion joint repair system manufacturer.

3.7 CRACK INJECTION

A. Examine areas under which injection Work will be installed and locate cracks that require injection. Identify and inject cracks greater than 0.010-inch wide in structures that retain or contain water, wastewater, or similar liquid.

B. Install injection material in accordance with crack injection manufacturer's requirements.

C. After injecting and curing, verify that injected material penetrated the crack adequately and that there is no visible leakage through the crack. After injecting, if crack continues to leak, re-inject crack at no additional cost to OWNER until structure is watertight.

D. If proper penetration of crack cannot be achieved, submit to ENGINEER a proposed alternate approach for modifying the specified injection procedure to properly seal the crack. In new concrete and in concrete cracked as a result of CONTRACTOR's operations, perform modifications to crack injection procedure and fully repair the crack without additional cost to OWNER or extension of the Contract Times.

3.8 POLYURETHANE COATING SYSTEM

A. Surface Preparation: Remove the following from surfaces to be repaired: laitance, foreign material, curing compounds, delaminated coating systems and any other contaminants. Additional surface preparation, if required, shall be as recommended by polyurethane coating system manufacturer.

B. Installation: Installation shall be as recommended by polyurethane coating system manufacturer.

3.9 SITE QUALITY CONTROL

A. Owner will employ and pay for services of testing laboratory for Site quality control testing. ENGINEER will direct the number of tests and specimens required, including providing necessary materials for making and facility for storing test specimens. Testing laboratory shall make standard compression test specimens as specified in this Section under the observation of ENGINEER. CONTRACTOR shall provide:
   1. Necessary assistance required by ENGINEER and Testing Laboratory.
   2. All labor, material, and equipment required, including rods, molds, thermometer, curing in heated storage box, and all other incidentals required, subject to approval by ENGINEER.
   3. All necessary storage, curing, and transportation required for testing.
   4. CONTRACTOR will be charged for cost of additional testing and investigation, if any, for Work performed that is not in accordance with the Contract Documents or is otherwise defective.

B. Site Tests of Cement-based Grouts and Repair Mortar:
   1. Obtain compression test specimens during construction from first placement of each type of mortar or grout, and at intervals thereafter as selected by ENGINEER, to verify compliance with the Contract Documents. Specimens will be made by ENGINEER or ENGINEER's representative.
   2. Compression tests and fabrication of specimens for repair mortar and non-shrink grout will be performed in accordance with ASTM C109. Set of three specimens will be made for each test. Tests will be made at seven days, 28 days, and additional time periods as deemed appropriate by ENGINEER.
   3. Material, already placed, failing to conform to the Contract Documents, is defective.

C. Repair Concrete: Repair concrete shall be tested as required in Section 03 00 05, Concrete.

++ END OF SECTION ++

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SECTION 05 05 33

ANCHOR SYSTEMS

PART 1 – GENERAL

1.1 DESCRIPTION

A. Scope:
   1. CONTRACTOR shall provide all labor, materials, equipment, and incidentals as shown, specified, and required to furnish and install anchor systems.
   2. This Section includes all anchor systems required for the Work, but not specified under other Sections.

B. Coordination:
   1. Review installation procedures under this and other Sections and coordinate installation of items to be installed with or before anchor systems Work.

1.2 REFERENCES

A. Standards referenced in this Section are:
   1. ACI 318, Building Code Requirements for Structural Concrete.
   2. ACI 350, Code Requirements for Environmental Engineering Concrete Structures.
   3. ACI 355.2, Qualification of Post-Installed Mechanical Anchors in Concrete.
   4. ANSI B212.15, Cutting Tools - Carbide-tipped Masonry Drills And Blanks For Carbide-tipped Masonry Drills.
   5. ANSI/MSS SP-58, Pipe Hangers and Supports – Materials, Design, Manufacture, Selection, Application, and Installation.
   6. ASTM A194/A194M, Specification for Carbon and Alloy Steel Nuts for Bolts for High Pressure or High Temperature Service, or Both.
   7. ASTM A276, Specification for Stainless Steel Bars and Shapes.
   8. ASTM A493, Specification for Stainless Steel Wire and Wire Rods for Cold Heading and Cold Forging.
   9. ASTM A563, Specification for Carbon and Alloy Steel Nuts.
   10. ASTM A1011/A1011M, 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.
   11. ASTM B633, Specification for Electrodeposited Coatings of Zinc on Iron and Steel.
   12. ASTM C881/C881M, Specification for Epoxy-Resin-Base Bonding Systems for Concrete.
   13. ASTM D695, Test Method for Compressive Properties of Rigid Plastics.

14. ASTM E329, Specification for Agencies Engaged in Construction Inspection, Testing, or Special Inspection.
15. ASTM E488, Test Methods for Strength of Anchors in Concrete and Masonry Elements.
16. ASTM F593, Specification for Stainless Steel Bolts, Hex Cap Screws, and Studs.
17. ASTM F594, Specification for Stainless Steel Bolts, Hex Cap Screws, and Studs.
18. ASTM F1554, Specification for Anchor Bolts, Steel, 36, 55 and 105-ksi Yield Strength.
19. FS A-A-1922A, Shield, Expansion (Caulking Anchors, Single Lead).
20. FS A-A-1923A, Concrete Expansion Anchors.
21. FS A-A-55614, Shield, Expansion (non-drilling expansion anchors).
22. ICC-ES AC01, Acceptance Criteria for Expansion Anchors in Masonry Elements.
23. ICC-ES AC 58, Acceptance Criteria for Adhesive Anchors in Masonry Elements.
24. ICC-ES AC193, Acceptance Criteria for Mechanical Anchors in Concrete Elements.
25. ICC-ES AC308, Acceptance Criteria for Post-Installed Adhesive Anchors in Concrete Elements.
26. NSF/ANSI 61, Drinking Water System Components – Health Effects.

1.3 QUALITY ASSURANCE

A. Qualifications:
   1. Testing Laboratory: Shall comply with ASTM E329 and shall be experienced in tension testing of post-installed anchoring systems.
   2. Post-installed Anchor Installer: Shall be experienced and trained by post-installed anchor system manufacturer in proper installation of manufacturer's products. Product installation training by distributors or manufacturer's representatives is unacceptable unless the person furnishing the training is qualified as a trainer by the anchor manufacturer.

1.4 SUBMITTALS

A. Action Submittals: Submit the following:
   1. Shop Drawings:
      a. Listing of all anchor systems products intended for use in the Work including product type, intended location in the Project, and embedded lengths.
   2. Product Data:
      a. Manufacturer's specifications, load tables, dimension diagrams, acceptable base material conditions, acceptable drilling methods, and acceptable bored hole conditions.

b. When required by ENGINEER, copies of valid ICC ES reports that presents load-carrying capacities and installation requirements for anchor systems.

B. Informational Submittals: Submit the following:
   1. Certificates:
      a. For each type of anchor bolt or threaded rod, submit copies of laboratory test reports and other data required to demonstrate compliance with the Contract Documents.
      b. Post-installed anchor system manufacturer's certification that installer received training in the proper installation of manufacturer's products required for the Work.
   2. Manufacturer's Instructions:
      a. Installation instructions for each anchor system product proposed for use, including bore hole cleaning procedures and adhesive injection, cure and gel time tables, and temperature ranges (storage, installation and in-service).

1.5 DELIVERY, STORAGE AND HANDLING

A. Storage and Protection:
   1. Keep materials dry during delivery and storage.
   2. Store adhesive materials within manufacturer's recommended storage temperature range.
   3. Protect anchor systems from damage at the Site. Protect products from corrosion and deterioration.

PART 2 – PRODUCTS

2.1 SYSTEM PERFORMANCE

A. General:
   1. At locations where conditions dictate that Work specified in other Sections is to be of corrosion resistant materials, provide associated anchor systems of stainless steel materials, unless other corrosion-resistant anchor system material is specified. Provide anchor systems of stainless steel materials where stainless steel materials are required in the Contract Documents.
   2. Stainless Steel Nuts:
      a. For anchor bolts and adhesive anchors, provide ASTM A194/A194M, Grade 8S (Nitronic 60) stainless steel nuts for stainless steel anchors used for anchoring equipment, gates, and weirs, and other locations, if any, where the attachment will require future removal for operation or maintenance. Provide lock washer or double nuts on each anchorage device provided for equipment, as required by equipment manufacturer.

b. For other locations, provide for each anchorage device a nut as specified or as required by anchor manufacturer. When ASTM A194/A194M, Grade 8S (Nitronic 60) nuts are not required for anchor bolts and adhesive anchors as specified in this Section, provide anti-seizing compound where stainless steel rods are used with stainless steel nuts of the same type.

3. Materials that can contact potable water or water that will be treated to become potable shall be listed in NSF/ANSI 61.

B. Design Criteria

1. Size, Length, and Load-carrying Capacity: Comply with the Contract Documents. When size, length or load-carrying capacity of anchor system is not otherwise shown or indicated, provide the following:

a. Anchor Bolts: Provide size, length, and capacity required to carry design load based on values and requirements of Paragraph 3.2.A of this Section. For conditions outside limits of critical edge distance and spacing in Paragraph 3.2.A of this Section, minimum anchor bolt embedment as shown or indicated in Paragraph 3.2.A of this Section apply and capacity shall be based on requirements of Laws and Regulations, including applicable building codes.

b. Adhesive Anchors, Expansion Anchors, or Concrete Inserts: Provide size, length, type, and capacity required to carry design load. Anchor capacity shall be based on the procedures required by the building code in effect at the Site. Where Evaluation Service Reports issued by the ICC Evaluation Service are required in this Section, anchor capacities shall be based on design procedure required in the applicable ICC Evaluation Service Report.

1) General: Determine capacity considering reductions due to installation and inspection procedures, embedment length, strength of base fastening materials, spacing, and edge distance, as indicated in the manufacturer's design guidelines. For capacity determination, concrete shall be assumed to be in the cracked condition, unless calculations demonstrate that the anchor system will be installed in an area that is not expected to crack under any and all conditions of design loading.

2) Concrete Adhesive Anchors: Unless otherwise shown or indicated in the Contract Documents or approved by ENGINEER, provide minimum embedment depth of the greater of the following: required to develop tensile strength of anchor, or a minimum embedment of 10 anchor diameters; and minimum anchor spacing and edge distance of 12 anchor diameters.

3) Concrete Masonry Adhesive Anchors: Unless otherwise shown or indicated in the Contract Documents or approved by ENGINEER, provide minimum anchor spacing and edge distance as indicated in anchor manufacturer's instructions.

4) Concrete Expansion Anchors: Unless otherwise shown or indicated in the Contract Documents or approved by ENGINEER, provide minimum embedment depth of six anchor diameters, and minimum anchor spacing and edge distance of seven anchor diameters.
5) Concrete Masonry Expansion Anchors: Unless otherwise shown or indicated in the Contract Documents or approved by ENGINEER, provide minimum anchor spacing and edge distance as indicated in anchor manufacturer's instructions.

2. Design Loads. Comply with the Contract Documents. When design load of supported material, equipment, or system is not otherwise shown or indicated, provide the following:
   a. Equipment Anchors: Use design load recommended by equipment manufacturer. When equipment can be filled with fluid, use loads that incorporate equipment load and load imposed by fluid.
   b. Pipe Hangers and Supports: Use full weight of pipe, and fluid contained in pipe that are tributary to the support plus the full weight of valves and accessories located between the hanger or support being anchored and the next hanger or support.
   c. Hangers and Supports for Electrical Systems, and HVAC, Plumbing, and Fire Suppression Systems and Piping: Use the full weight of supported system that is tributary to the support plus the full weight of accessories located between the hanger or support being anchored and the next hanger or support. When piping or equipment is to be filled with fluid, anchor systems shall be sized to support such loads in addition to the weight of the equipment, piping, or system, as applicable.
   d. Delegated Design: When anchor systems are used for supporting materials, equipment, or systems delegated to a design professional retained by CONTRACTOR, Subcontractor, or Supplier, provide anchor system suitable for loads indicated in delegated design documents and consistent with the design intent expressed in the Contract Documents.

C. Application:
   1. Anchor Bolts:
      a. Where anchor bolt is shown or indicated, use cast-in-place anchor bolt unless another anchor type is approved by ENGINEER.
      b. Provide anchor bolts as shown or indicated, or as required to secure structural element to appropriate anchor surface.
   2. Concrete Adhesive Anchors:
      a. Use where adhesive anchors are shown or indicated for installation in concrete.
      b. Suitable for use where subject to vibration.
      c. Suitable for use in exterior locations or locations subject to freezing.
      d. Suitable for use in submerged, intermittently submerged, or buried locations.

e. Do not use in overhead applications, unless otherwise shown or approved by ENGINEER.
f. Do not use for pipe hangers, unless otherwise shown or approved by ENGINEER.

3. Concrete Masonry Adhesive Anchors:
   a. Use where adhesive anchors are shown or indicated for installation in grout filled or hollow masonry units.
   b. Suitable for use where subject to vibration.
   c. Suitable for use in exterior locations or locations subject to freezing.
   d. Do not use for pipe hangers, unless otherwise shown or approved by ENGINEER.
4. Concrete Wedge Expansion Anchors:
   a. Use where expansion anchors are shown or indicated for installation in concrete.
   b. Do not use where subject to vibration.
   c. Do not use in exterior locations or locations subject to freezing.
   d. Do not use in submerged, intermittently submerged, or buried locations.
   e. Suitable for use in overhead applications.
5. Grout-filled Concrete Masonry Wedge Expansion Anchors:
   a. Use where expansion anchors are shown or indicated for installation on the interior face of grout-filled unit masonry.
   b. Do not use where subject to vibration.
   c. Do not use in exterior locations or locations subject to freezing.
6. Hollow Concrete Masonry Sleeve Expansion Anchors:
   a. Use where expansion anchors are shown or indicated for installation in hollow concrete unit masonry or solid brick.
   b. Do not use for attaching safety-related systems, such as piping conveying hazardous or potentially hazardous materials, or fire suppression systems.
   c. Do not use where subject to vibration.
   d. Do not use in exterior locations or locations subject to freezing.
7. Drop-in Expansion Anchors:
   a. Use drop-in expansion anchors installed in concrete where light-duty anchors are required to support piping or conduit two-inch diameter or smaller.
   b. Do not use for attaching safety-related systems, such as piping conveying hazardous or potentially hazardous materials, or fire suppression systems.
   c. Do not use where subject to vibration.
   d. Do not use at submerged, intermittently submerged, or buried locations.
   e. Do not use in exterior locations or locations subject to freezing.
   f. Suitable for use in overhead applications.
8. Concrete Inserts:
   a. Use only where shown or indicated in the Contract Documents.

b. Allowed for use to support pipe hangers and pipe supports for pipe size and loading recommended by the concrete insert manufacturer.

9. Drive-In Expansion Anchors:
   a. Use drive-in expansion anchors installed in concrete, precast concrete, grouted masonry units, or brick, where light-duty anchors are required to support piping or conduit one-inch diameter and smaller.
   b. Do not use for attaching safety-related systems, such as piping conveying hazardous or potentially hazardous materials, or fire suppression systems.
10. For Use in Precast Concrete Planks:
   a. To support piping or conduit six-inch diameter and smaller, use low-profile drop-in anchors, hollow concrete masonry adhesive anchors, or through-bolts.
   b. For piping greater than six-inch diameter, or to support safety-related systems, use through-bolts. Each through-bolt shall consist of threaded rod, nuts, washers, and bearing plate.

2.2 MATERIALS

A. Anchor Bolts:
   1. Provide stainless steel straight threaded rods complying with ASTM F593, AISI Type 316, Condition A, with ASTM F594, AISI Type 316, stainless steel nuts. Provide ASTM A194/A194M, Grade 8S (Nitronic 60) stainless steel nuts where required. Other AISI types may be used when approved by ENGINEER. Hooked bolts are unacceptable.
   2. Equipment: Provide anchor bolts complying with material requirements of this Section and equipment manufacturer's requirements relative to size, embedment length, and anchor bolt projection. Anchor bolts shall be straight threaded rods with washers and nuts as specified in this Section. Hooked bolts are unacceptable.
   3. Anchoring of Structural Elements: Provide anchor bolts of size, material, and strength shown or indicated in the Contract Documents.

B. Concrete Adhesive Anchors:
   1. General:
      a. Adhesive anchors shall consist of threaded rods anchored into hardened concrete using an adhesive system.
   2. Products and Manufacturers: Provide one of the following:
      a. HIT-RE 500-SD Injection Epoxy Adhesive Anchoring System, by Hilti Fastening Systems, Inc.
      b. SET-XP Epoxy-Tie Adhesive, by Simpson Strong-Tie Company, Inc.
      c. Or equal.
   3. Adhesive:
      a. Adhesive system shall use two-component adhesive mix.

b. Epoxy adhesives shall comply with physical requirements of ASTM C881/C881M, Type IV, Grade 2 and 3, Class A, B, and C, except gel times.

c. Adhesives shall have a current evaluation report by ICC Evaluation Service for use in both cracked and uncracked concrete with seismic recognition for SDC A through F as tested and assessed in accordance with ICC-ES AC308.

d. Adhesives shall have minimum bond strength and minimum design bond strength (bond strength multiplied by strength reduction factor) in accordance with Table 05 05 33-A:

TABLE 05 05 33-A:
ADHESIVE BOND STRENGTH [1,2]

Anchor	Uncracked Concrete		Cracked Concrete	
Rod Diameter / Dowel Size	Bond Strength (psi)	Design Bond Strength (psi)	Bond Strength (psi)	Design Bond Strength (psi)
3/8-inch / #3	2040	1300	1090	700
1/2-inch / #4	1920	1200	920	560
5/8-inch / #5	1830	1150	710	390
3/4-inch / #6	1760	1050	710	460
7/8inch / #7	1670	900	610	340
1-inch / #8	1650	1050	850	460
- / #9	1900	1000	800	400
1.25-inch/ #10	1580	1000	730	400

Table Notes:
1. Bond strengths listed for hammer-drilled, dry hole.
2. Bond strengths listed for maximum short term concrete temperature of 110 degrees F and maximum long term concrete temperature of 75 degrees F.

4. Anchor:
   a. Provide continuously-threaded, AISI Type 316 stainless steel adhesive anchor rod. Threaded rods shall comply with the concrete adhesive anchor manufacturer's specifications as included in the ICC Service Evaluation Report for the anchor submitted. Nuts shall have specified proof load stresses equal to or greater than the minimum tensile strength of the stainless steel threaded rod used. Provide ASTM A194/A194M, Grade 8S (Nitronic 60) stainless steel nuts where required.

C. Concrete Masonry Adhesive Anchors:
   1. General:
      a. Grout-filled Concrete Masonry Adhesive anchors shall consist of threaded rods anchored into grout-filled concrete block masonry using an adhesive system.

b. Hollow Concrete Masonry Adhesive Anchors shall consist of threaded rods with a cylindrical mesh steel or plastic screen tube anchored into hollow concrete block masonry using an adhesive system.

2. Products and Manufacturers: Provide one of the following:
   a. HIT-HY 70 Hybrid Adhesive Anchor System, by Hilti Fastening Systems, Inc.
   b. Acrylic-Tie Adhesive, by Simpson Strong-Tie Company, Inc.
   c. Or equal.
3. Adhesive:
   a. Adhesive system shall use two-component adhesive mix.
   b. Hybrid adhesives shall comply with the following:
      1) ASTM D695 compressive yield strength greater than 7,200 psi on a 7 day cure.
   c. Adhesives shall have current ICC Evaluation Service Report for use in grout-filled concrete masonry, tested and assessed in accordance with ICC-ES AC 58.
4. Anchor:
   a. Provide stainless steel adhesive anchor rod complying with ASTM F593, AISI Type 316, Condition CW, with ASTM F594, AISI Type 316 stainless steel nuts. Provide ASTM A194/A194M, Grade 8S (Nitronic 60) stainless steel nuts where required.
5. Mesh Screen Tube (for hollow masonry applications):
   a. Provide with mesh size, material, length, and diameter as required by adhesive anchor manufacturer.

D. Concrete Wedge Expansion Anchors:
1. General:
   a. Concrete wedge expansion anchors shall consist of stud, wedge, nut, and washer.
2. Products and Manufacturers: Provide one of the following:
   a. Kwik Bolt TZ Wedge Anchor, by Hilti Fastening Systems, Inc.
   b. Strong Bolt 2 Wedge Anchor, by Simpson Strong-Tie Company, Inc.
   c. Or equal.
3. Anchors shall comply with physical requirements of FS A-A-1923A, Type 4. Provide concrete wedge expansion anchors suitable for use in cracked and uncracked concrete in accordance with ACI 318 and ACI 350, Appendix D. Demonstrate suitability of cracked concrete wedge anchors in accordance with ACI 355.2 prequalification tests.
4. Interior Dry Non-corrosive Locations: Provide carbon steel anchors complete with nuts and washers, zinc plated, in accordance with ASTM B633.
5. Other Locations: Provide expansion anchors complete with nuts and washers, AISI Type 304 stainless steel anchor body, in accordance with ASTM A276 or ASTM A493.
6. Concrete wedge expansion anchors shall have a current ICC Evaluation Service Report for use in both cracked and uncracked concrete with seismic

recognition in seismic design Categories A through F when tested and assessed in accordance with ICC-ES AC193.

E. Grout-filled Masonry Wedge Expansion Anchors:
   1. General:
      a. Grout-filled masonry wedge expansion anchors shall each consist of stud, wedge, nut, and washer.
   2. Product and Manufacturers: Provide one of the following:
      a. Kwik-Bolt 3 Expansion Anchors, by Hilti Fastening Systems, Inc.
      b. Wedge-All Wedge Anchors, by Simpson Strong-Tie Company, Inc.
      c. Or equal.
   3. Anchors shall comply with physical requirements of FS A-A-1923A, Type 4. Anchors shall be non-bottom bearing type with single-piece steel expansion clip providing 360-degree contact with base material and shall not require oversized holes for installation.
   4. Interior Dry Non-corrosive Locations: Provide carbon steel anchors complete with nuts and washers, zinc plated, in accordance with ASTM B633.
   5. Other Locations: Provide AISI Type 316 stainless steel anchor, complete with nut and washer, in accordance with ASTM A276 or ASTM A493.
   6. Grout-filled masonry wedge expansion anchors shall have a current ICC Evaluation Service report for use in fully-grouted concrete masonry construction when tested and assessed in accordance with ICC-ES AC01.

F. Hollow Concrete Masonry Sleeve Expansion Anchors:
   1. General:
      a. Sleeve expansion anchors shall each consist of an externally threaded stud with full length expanding sleeve.
   2. Products and Manufacturers: Provide one of the following:
      a. HLC Sleeve Anchors, by Hilti Fastening Systems, Inc.
      b. Dynabolt Sleeve Anchors, by ITW Red Head.
      c. Or equal.
   3. Anchors shall comply with physical requirements of FS A-A-1922A. Anchors shall be non-bottom bearing type with single-piece steel expansion sleeve providing 360-degree contact with base material, and shall not require oversized holes for installation.
   4. Interior Dry Non-corrosive Locations: Provide carbon steel anchors complete with nuts and washers, zinc plated, in accordance with ASTM B633.
   5. Other Locations: Provide expansion anchors complete with nuts and washers, Type 304 stainless steel, in accordance with ASTM A276 or ASTM A493.

G. Drop-in Expansion Anchors:
   1. General:

a. Drop-in expansion anchors shall each consist of an internally threaded, deformation-controlled expansion anchor with pre-assembled expander plug.

2. Products and Manufacturers: Provide one of the following:
   a. HDI Drop-In Anchors, by Hilti Fastening Systems, Inc.
   b. Drop-In Anchor, by Simpson Strong-Tie Company, Inc.
   c. Or equal.
3. Provide carbon steel anchors complete with nuts and washers, zinc plated, in accordance with ASTM B633, complying with physical requirements of FS A-A-55614, Type I. Anchors shall be flush or shell type. Provide low-profile anchors for use in precast concrete planks.

. H. Drive-In Expansion Anchors:
1. General:
   a. Drive-In expansion anchors shall each consist of stainless steel drive pin and expanding alloy body.
2. Products and Manufacturers: Provide one of the following:
   a. Metal HIT Anchor, by Hilti Fastening Systems, Inc.
   b. Zinc Nailon Anchor, by Simpson Strong-Tie Company, Inc.
   c. Or equal.
3. Provide Type 304 stainless steel drive pin with zinc alloy body. Anchor shall comply with physical requirements of FS A-A-1925A, Type 1.

I. Unless approved by ENGINEER, do not use power-actuated fasteners or other types of bolts and fasteners not specified in this Section.

J. Anti-Seizing Compound:
1. Products and Manufacturers: Provide one of the following:
   a. Pure Nickel Never-Seez, by Bostik.
   b. Nickel-Graf, by Anti-Seize Technology.
   c. Or equal.
2. Provide pure nickel anti-seizing compound.

PART 3 – EXECUTION

3.1 INSPECTION

A. Examine conditions under which materials will be installed and advise ENGINEER in writing of conditions detrimental to proper and timely completion of the Work. Do not proceed with the Work until unsatisfactory conditions are corrected.

3.2 INSTALLATION

A. Anchor Bolts:

1. Provide anchor bolts as shown or indicated in the Contract Documents, or as required to secure structural element to the appropriate anchor surface.
2. Locate and accurately set anchor bolts using templates or other devices as required, prior to placing concrete. Wet setting of anchor bolts is unacceptable.
3. Protect threads and shank from damage during installation and subsequent construction operations.
4. Unless otherwise shown or approved by ENGINEER anchor bolts shall comply with Table 05 05 33-B:

TABLE 05 05 33-B:
SINGLE ANCHOR ALLOWABLE LOADS ON ANCHOR BOLTS [1]

Bolt Diameter (inch)	F1554 Grade 36 F593 Type 316, Condition A				F1554 Grade 55			
	Minimum Embedment (inch)	Minimum Edge Distance and Spacing[2] (inch)	Shear[3,4] (lb)	Tension[3] (lb)	Minimum Embedment (inch)	Minimum Edge Distance and Spacing[2] (inch)	Shear[3] (lb)	Tension[3] (lb)
1/2	6	9	1,262	2,420	8.5	12.75	1,660	3,190
5/8	7.5	11.25	2,010	3,860	10.5	15.75	2,640	5,080
3/4	9	13.5	2,974	5,720	13	19.5	3,910	7,520
7/8	10.5	15.75	4,106	7,890	15	22.5	5,400	10,390
1	12	18	5,386	10,360	17	25.5	7,090	13,450
1 1/8	13.5	20.25	6,787	13,052	19	28.5	8,930	16,580
1 1/4	15	22.5	8,617	16,572	21	31.5	11,340	20,040

Table Notes:
1. Table is based on ACI 318 and ACI 350, Appendix D, f'_c = 4000 psi. Table 05 05 33-B is not applicable to anchor bolts embedded in grouted masonry.
2. Critical edge distance and spacing are indicated in the table. Capacity of anchor bolts for other combination of edge distances and spacing shall be evaluated in accordance with ACI 318 and ACI 350, Appendix D.

3. Values for shear and tension listed are not considered to act concurrently. Interaction of tension and shear will be evaluated by ENGINEER in accordance with ACI 318 and ACI 350, Appendix D.

B. Adhesive Anchors and Expansion Anchors – General:
   1. Prior to drilling, locate existing reinforcing steel in vicinity of proposed holes. If reinforcing conflicts with proposed hole location, obtain ENGINEER's approval of alternate hole locations to avoid drilling through or damaging existing reinforcing bars.

C. Adhesive Anchors:
   1. Comply with manufacturer's written installation instructions and the following.
   2. Drill holes to adhesive system manufacturer's recommended drill bit diameter to the specified depth. Drill holes in hammering and rotation mode with carbide-tipped drill bits that comply with the tolerances of ANSI B212.15. Core-drilled holes are unacceptable.
   3. Before setting adhesive anchor, hole shall be made free of dust and debris by method recommended by adhesive anchor system manufacturer. Hole shall be brushed with adhesive system manufacturer-approved brush and blown clean with clean, dry, oil-free compressed air to remove all dust and loose particles. Hole shall be dry as defined by adhesive system manufacturer.
   4. Before injecting adhesive, obtain ENGINEER's concurrence that hole is dry and free of oil and other contaminants.
   5. Prior to injecting adhesive into the drilled hole, dispense, to a location appropriate for such waste, an initial amount of adhesive from the mixing nozzle, until adhesive is uniform color.
   6. Inject adhesive into hole through injection system-mixing nozzle and necessary extension tubes, placed to bottom of hole. Discharge end shall be withdrawn as adhesive is placed but kept immersed to prevent formation of air pockets. Fill hole to depth that ensures that excess material is expelled from hole during anchor placement.
   7. Twist anchors during insertion into partially-filled hole to guarantee full wetting of rod surface with adhesive. Insert rod slowly to avoid developing air pockets.
   8. Provide adequate curing in accordance to adhesive system manufacturer's requirements prior to continuing with adjoining Work that could place load on installed adhesive anchors. Do not begin adjoining Work until adhesive anchors are successfully tested or when allowed by ENGINEER.
   9. Limitations:
      a. Installation Temperature: Comply with manufacturer's instructions for installation temperature requirements. Provide temporary protection and other measures, such as heated enclosures, necessary to ensure that base material temperature complies with anchor systems

manufacturer's requirements during installation and curing of adhesive anchor system.

b. Oversized Holes: Advise ENGINEER immediately if size of drilled hole is larger than recommended by anchor system manufacturer. Cost of corrective measures, including but not limited to redesign of anchors due to decreased anchor capacities, shall be paid by CONTRACTOR.

c. Embedment depths shall be based on installation in normal-weight concrete with compressive strength of 2,500 psi when embedded in existing concrete, and 4,000 psi when embedded in new concrete.

D. Expansion Anchors:

1. Comply with expansion anchor manufacturer's written installation instructions and the following:
2. Drill holes using anchor system manufacturer's recommended drill bit diameter and to the specified depth. Drill holes in hammering and rotation mode with carbide-tipped drill bits complying with tolerances of ANSI B212.15. Core drilled holes are unacceptable.
3. Before installing anchor, hole shall be made free of dust and debris by method recommended by anchor system manufacturer. Hole shall be brushed with anchor system manufacturer-approved brush and blown clean with clean, dry, oil-free compressed air to remove all dust and loose particles.
4. Before installing anchor, obtain ENGINEER's concurrence that hole is dry and free of oil and other contaminants.
5. Protect threads from damage during anchor installation. Drive anchors not less than four threads below surface of the attachment. Set anchors to anchor manufacturer's recommended torque using a torque wrench.

E. Concrete Inserts:

1. Comply with concrete insert manufacturer's installation instructions.
2. Inserts shall be flush with slab bottom surface.
3. Protect embedded items from damage during concrete placing. Ensure that embedded items are securely fastened to prevent movement during concrete placing, and ensure that embedded items do fill with concrete during concrete placing.
4. Inserts intended for piping greater than four-inch diameter shall be provided with hooked rods attached to concrete reinforcing.

F. Anti-Seizing Compound:

1. Provide anti-seizing compound in accordance with anti-seizing compound manufacturer's installation instructions, at locations indicated in Paragraph 2.1.B of this Section.
2. Do not use anti-seizing compound at locations where anchor bolt or adhesive anchor will contact potable water or water that will be treated to become potable.

3.3 CLEANING

A. After embedding concrete is placed, remove protection and clean bolts and inserts.

3.4 FIELD QUALITY CONTROL

A. Site Tests:
   1. Owner will employ services of testing agency to perform field quality tensile testing of production adhesive anchors at the Site, unless otherwise specified.
      a. Testing shall comply with ASTM E488.
      b. Test at least ten percent of all types of adhesive anchors. If one or more adhesive anchors fail the test, CONTRACTOR shall pay cost of testing, or at ENGINEER's option CONTRACTOR may arrange for testing paid by CONTRACTOR, for all adhesive anchors of same diameter and type installed on the same day as the failed anchor. If anchors installed on the same day as the failed anchor also fail the test, ENGINEER may require retesting of all anchors of the same diameter and type installed in the Work. CONTRACTOR shall be responsible for retesting costs.
      c. ENGINEER will direct which adhesive anchors are to be tested and indicate test load to be used
      d. Apply test loads with hydraulic ram.
      e. Displacement of post-installed anchors shall not exceed D/10, where D is nominal diameter of anchor being tested.
   2. Correct defective Work by removing and replacing or correcting, as directed by ENGINEER.
   3. CONTRACTOR shall pay for all corrections and subsequent testing required to confirm competence in the installation of post-installed mechanical anchors.
   4. Testing agency shall submit test results to CONTRACTOR and ENGINEER within 24 hours of completion of test.

B. Manufacturer's Services:
   1. Provide at the Site services of qualified adhesive manufacturer's representative during initial installation of adhesive anchor systems to train CONTRACTOR's personnel in proper installation procedures. Manufacturer's representative shall observe to confirm that installer demonstrates proper installation procedures for adhesive anchors and adhesive material.

++ END OF SECTION ++

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SECTION 05 50 13

MISCELLANEOUS METAL FABRICATIONS

PART 1 – GENERAL

1.1 DESCRIPTION

A. Scope:
   1. CONTRACTOR shall provide all labor, materials, equipment, and incidentals as shown, specified, and required to furnish miscellaneous metal fabrications including surface preparation and shop priming.
   2. The Work also includes:
      a. Providing openings in miscellaneous metal fabrications to accom-modate the Work under this and other Sections, and attaching to miscellaneous metal fabrications all items such as sleeves, bands, studs, fasteners, and all items required for which provision is not specifically included under other Sections.

B. Coordination:
   1. Review installation procedures under this and other Sections and coordinate the Work to be installed with, or attached to miscellaneous metal fabrications Work.
   2. Hot-dip Galvanizing: Coordinate with steel fabricator detailing for and fabrication of assemblies to be hot-dip galvanized, to minimize distortion during galvanizing process.

C. Related Sections:
   1. Section 05 05 33, Anchor Systems.
   2. Section 09 91 00, Painting,

1.2 REFERENCES

A. Standards referenced in this Section are:
   1. ASTM A36/A36M, Specification for Carbon Structural Steel.
   2. ASTM A53/A53M, Specification for Pipe Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless.
   3. ASTM A123/A123M, Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
   4. ASTM A153/A153M, Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.

5. ASTM A240/A240M, Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet and Strip for Pressure Vessels and for General Applications.
6. ASTM A384/A384M, Practice for Safeguarding Against Warpage and Distortion During Hot-Dip Galvanizing of Steel Assemblies.
7. ASTM A500, Specification for Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes.
8. ASTM A572/A572M, Specification for High-Strength Low-Alloy Columbium-Vanadium Structural Steel.
9. ASTM A992/A992M, Specification for Structural Steel Shapes.
10. ASTM B209, Specification for Aluminum and Aluminum-Alloy Sheet and Plate.
11. ASTM B211, Specification for Aluminum and Aluminum-Alloy Bar, Rod and Wire.
12. ASTM B221, Specification for Aluminum and Aluminum-Alloy Extruded Bars, Rods, Wire, Profiles, and Tubes.
13. ASTM B308/B308M, Specification for Aluminum-Alloy 6061-T6 Standard Structural Profiles.
14. ASTM B429, Specification for Aluminum-Alloy Extruded Structural Pipe and Tube.
15. ASTM B632/B632M, Specification for Aluminum-Alloy Rolled Tread Plate.
16. AWS D1.1/D1.1M, Structural Welding Code – Steel.
17. AWS D1.2/D1.2M, Structural Welding Code – Aluminum.
18. AWS D1.6, Structural Welding Code – Stainless Steel.

1.3 QUALITY ASSURANCE

A. Qualifications:
   1. Welding:
      a. Qualify welding processes and welding operators in accordance with AWS D1.1/D1.1M, D1.2/D1.2M, or D1.6, as applicable.
      b. When requested by ENGINEER, provide certification that each welder employed on or to be employed for the Work have satisfactorily passed AWS qualification tests within previous 12 months. Ensure that all certifications are current.

B. Regulatory Requirements: Conform to the following:
   1. 29 CFR 1910, Occupational Health and Safety Standards.

1.4 SUBMITTALS

A. Action Submittals: Submit the following:
   1. Shop Drawings:
      a. Fabrication and erection details for assemblies of miscellaneous metal Work. Include plans, elevations, and details of sections and connections.

Show anchorage and accessory items. Include setting drawings and templates for locating and installing miscellaneous metal items and anchorage devices.

2. Product Data:
   a. Copies of manufacturer's specifications, load tables, dimension diagrams, anchor details, and installation instructions for products to be used in miscellaneous metal Work.

B. Informational Submittals: Submit the following:
   1. Test and Evaluation Reports:
      a. Mill test report that indicate chemical and physical properties of each type of material, when requested by ENGINEER.
   2. Qualifications Statements:
      a. Copies of welder's certifications, when requested by ENGINEER.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Packing, Shipping, Handling and Unloading:
   1. Deliver products to Site to ensure uninterrupted progress of the Work. Deliver anchorage materials to be embedded in other construction in ample time to prevent delaying the Work.

PART 2 – PRODUCTS

2.1 MATERIALS

A. Steel:
   1. W-Shapes and WT-Shapes: ASTM A992/A992M.
   2. S-Shapes and Channels: ASTM A572/A572M, Grade 50.
   3. Hollow Structural Sections: ASTM A500, Grade B.
   4. Angles, Plates, Bars: ASTM A36/A36M.
   5. Steel Pipe: ASTM A53/A53M, Grade B.

B. Aluminum:
   1. Aluminum Shapes: ASTM B308/B308M, Alloy 6061-T6, ASTM B 221, Alloy 6061-T6.
   2. Aluminum Tubes and Pipes: ASTM B429, Alloy 6061-T6.
   3. Aluminum Bars and Rod: ASTM B211, Alloy 6061-T6.
   4. Aluminum Plates: ASTM B209, Alloy 6061-T6.

C. Stainless Steel:
   1. Plates and Sheets: ASTM A240/A240M, Type 304L or Type 316 stainless steel.
   2. Submerged or Intermittently Submerged: Type 316 stainless steel.

3. Non-submerged: Type 304L stainless steel.

D. Stainless Steel Fasteners and Fittings: ASTM A 320/A 320M, Type 304L or Type 316 Stainless Steel.

E. Zinc-coated Hardware: ASTM A153/A153M.

F. Aluminum Grating frames: Aluminum alloy 6061-T6 or alloy 6063-T6, complying with ASTM B221 with Type 316 stainless steel welded stud anchors and other fasteners.

2.2 MISCELLANEOUS METAL ITEMS

A. Shop Assembly:
1. Pre-assemble items in the shop to the greatest extent possible to minimize field-splicing and field-assembly of units at the Site. Disassemble units only to extent necessary for shipping and handling limitations. Clearly mark units for reassembly and coordinated installation.

B. Steel Lintels:
1. Provide loose structural steel lintels for openings and recesses in masonry walls and brick walls as specified or as shown.
2. Weld adjoining members together to form a single unit, where shown or indicated.
3. Provide not less than eight inches bearing at each side of openings, unless otherwise shown.
4. Steel lintels to be installed in exterior walls shall be hot-dip galvanized and finish painted. Other steel lintels shall be painted.
5. Surface preparation and painting shall conform to Section 09 91 00, Painting.
6. Where lintels are not shown on the Drawings, provide lintels as specified in the following table. Provide other lintels where shown and of size indicated on the Drawings.

Clear Span (Max)	**Exterior Angle**	**Interior Angles (typical 8-inch wall)**
4.0 feet	3.5 inches by 3.5 inches by 5/16 inches	Two 3.5 inches by 3.5 inches by 5/16 inches
6.0 feet	Four inches by 3.5-inches by 5/16 inches	Two 4 inches by 3.5 inches by 5/16 inches
8.0 feet	Five inches by 3.5 inches by 5/16 inches	Two 5 inches by 3.5 inches by 5/16 inches

C. Shelf Angles:

1. Provide structural steel shelf angles of sizes shown, for attachment to concrete or masonry construction. Provide slotted holes to receive 3/4-inch bolts, spaced not more than six inches from ends and not more than 2.0 feet on centers, unless otherwise shown.
    a. Provide galvanized shelf angles on outdoor construction.
2. Provide wedge-type concrete inserts, complete with fasteners, for attachment of shelf angles to cast-in-place concrete.

D. Steel Ladders:
1. Fabricate ladders for locations shown or indicated with dimensions, spacing, details, and anchorages as shown or specified. Comply with OSHA 29 CFR 1910 and ANSI A14.3, except as otherwise shown or specified.
    a. Unless otherwise shown, provide 2.5-inch by 0.375 inch flat bars for stringers, spaced at least 1.5 feet apart.
    b. Provide 0.75 inch diameter steel rod rungs, spaced maximum of 12 inches on centers, with non-slip surface on top of each rung. Adhesive strips for non-slip surfaces are not acceptable.
2. Fit rungs in centerline of side rails, plug weld, and grind smooth on outer rail faces.
3. Support each ladder at top and bottom and at intermediate points spaced not more than four feet on centers.
4. Use welded or bolted brackets, designed for adequate support and anchorage, and to hold ladder clear of wall surface with minimum of seven inches between wall and centerline of rungs.
5. Unless otherwise shown or approved by ENGINEER, extend rails 3.5 feet above top rung, and return rails to wall or structure, unless other secure handholds are provided. If adjacent structure does not extend above top rung, goose-neck extended rails back to structure to provide secure ladder access.

E. Davit Crane Flush Mounted Floor Sleeve:
1. Provide stainless steel floor mounted sleeve with welded steel studs for embedment into fresh concrete. Sleeve shall be 4" in diameter and include PVC liner and sleeve cover.
2. Products and Manufacturers: Provide products of one of the following:
    a. Flush Floor Mount Sleeve, Model #8512828 by DBI-Sala.
    b. Or equal.

F. Miscellaneous Framing and Supports:
1. Provide miscellaneous metal framing and supports that are not part of structural steel framework and are required to complete the Work.
2. Fabricate miscellaneous units to sizes, shapes, and profiles shown on the Drawings or, if not shown, of required dimensions to receive adjacent grating, plates, tanks, doors, and other work to be retained by the framing.

3. Except as otherwise shown, fabricate from structural shapes, plates, and bars, of all-welded construction using mitered corners, welded brackets, and splice plates and minimum number of joints for field connection.
4. Cut, drill, and tap units to receive hardware and similar items to be anchored to the Work.
5. Furnish units with integrally welded anchors for casting into concrete or building into masonry. Furnish inserts if units are to be installed after concrete is placed.
    a. Except as otherwise shown, space anchors, 2.0 feet on centers, and provide units the equivalent of 1.25-inch by 1/4-inch by eight-inch strips.
    b. Galvanize exterior miscellaneous frames and supports.
    c. Where shown or indicated, galvanize miscellaneous frames and supports that are not to be installed outdoors.
6. Miscellaneous steel framing and supports shall be hot-dip galvanized and finish-painted, unless otherwise shown or indicated.
7. For railings, refer to Section 05 52 15, Aluminum Handrails and Railing.
8. For grating requirements refer to Section 05 53 16, Aluminum Grating.
9. Surface preparation and painting of galvanized surface shall conform to Section 09 91 00, Painting

G. Aluminum Raised-pattern Floor Plate:
1. Provide raised-pattern floor plate conforming to ASTM B632/B632M and manufacturer's standards. Provide plates of thicknesses shown.
2. Products and Manufacturers: Provide products of one of the following:
    a. 4-Way Safety Aluminum Plate, by Ryerson Tull Company.
    b. Raised Pattern Floor Aluminum Plate, by Central Steel and Wire Company.
    c. Or equal.
3. Provide removable plates at locations and sizes shown. Provide perforated plates where shown.
4. Provide each plate section with four lifting handles as recommended by manufacturer. Lifting handles shall be recessed, drop handle type. Maximum weight of checkered plate or plank section shall be 150 pounds.
5. Finish: Anodized. Protect finish with factory-applied coating of manufacturer's standard lacquer coating, suitable for service on floor.

H. Provide existing aluminum gratings and checkered plate in concrete with aluminum angle frames with mitered corners and welded joints. Grind exposed joints smooth. Frames shall have welded anchors set into concrete. Angle size shall match grating depth selected for flush fit in accordance with the details shown on the Drawings.

I. Fasteners and Hardware: Provide Type 316 stainless steel fasteners for aluminum fabrications and zinc-coated hardware for galvanized fabrications, unless otherwise shown or specified.

J. Anchors and Expansion Anchors: Refer to Section 05 05 33, Anchor Systems.

2.3 FINISHING

A. Surface Preparation and Shop Priming: Perform surface preparation and apply primer coat to miscellaneous metal fabrications in the shop. Conform to surface preparation and shop priming requirements in Section 09 91 00, Painting.

B. Galvanizing:
   1. Galvanizing of fabricated steel items shall comply with ASTM A123/A123M.
   2. Details of fabrication of steel items and assemblies to be hot-dip galvanized shall conform to recommendations of ASTM A384/A384M to minimize the potential for distortion.

C. Aluminum Finish: Provide natural mill finish for aluminum Work unless otherwise shown or specified.

2.4 SOURCE QUALITY CONTROL

A. Tests and Inspections:
   1. Materials and fabrication procedures shall be subject to inspection and tests in the mill, shop, and field, conducted by a qualified inspection agency. Such inspections and tests will not relieve CONTRACTOR of responsibility for providing materials and fabrication procedures complying with the Contract Documents.

PART 3 – EXECUTION

3.1 EXAMINATION

A. Examine conditions under which the Work is to be performed and notify ENGINEER in writing of conditions detrimental to the proper and timely completion of the Work. Do not proceed with the Work until unsatisfactory conditions are corrected.

3.2 INSTALLATION

A. Install miscellaneous metal fabrications accurately in location, alignment, and elevation, plumb, level, true, and free of rack, measured from established lines and levels. Brace temporarily or anchor temporarily in formwork where fabrications are to be built into concrete, masonry, or other construction.

B. Anchor securely as shown and as required for the intended use, using concealed anchors where possible.

C. Fit exposed connections accurately together to form tight, hairline joints. Field-weld steel connections that are not to be exposed joints and cannot be shop-welded because of shipping size limitations. Comply with AWS D1.1/D1.1M, D1.2/D1.2M and D1.6, as applicable to the material being welded. Grind steel joints smooth and touch-up shop paint coat. Do not weld, cut, or abrade surfaces of exterior units that have been hot-dip galvanized after fabrication, and are intended for bolted or screwed field connections.

D. Protection of Aluminum from Dissimilar Materials:
   1. Coat surfaces of aluminum that will contact dissimilar materials such as concrete, masonry, and steel, in accordance with Section 09 91 00, Painting.

+ + END OF SECTION + +

SECTION 06 10 53

MISCELLANEOUS ROUGH CARPENTRY

PART 1 – GENERAL

1.1 DESCRIPTION

A. Scope:
   1. CONTRACTOR shall provide all labor, material, tools, equipment, and incidentals as shown, specified, and required to furnish and install all miscellaneous rough carpentry Work.
   2. The Work also includes:
      a. Providing openings in miscellaneous rough carpentry to accommodate the Work under this and other Sections and building into miscellaneous rough carpentry items such as sleeves, anchorages, inserts and other items to be embedded in or penetrating miscellaneous rough carpentry for which placement is not specifically provided under other Sections.
   3. Types of materials required include:
      a. Miscellaneous blocking, furring strips, and other miscellaneous wood framing.
      b. Lumber for temporary protection.
      c. Lumber for temporary support.
      d. Miscellaneous accessories.

B. Coordination:
   1. Review installation procedures under this and other Sections and coordinate installation of items to be installed with or before miscellaneous rough carpentry Work.

C. Related Sections:
   1. Section 05 05 33, Anchor Systems.

1.2 REFERENCES

A. Standards referenced in this Section are:
   1. ALSC PS 20, American Softwood Lumber Standard.
   2. ASME B18.2.1 Square and Hex Bolts and Screws, Inch Series.
   3. ASME B18.6.1 Wood Screws, Inch Series.
   4. ASTM F1667, Specification for Driven Fasteners: Nails, Spikes, and Staples.
   5. NIST PS-1, Construction and Industrial Plywood.
   6. Southern Pine Inspection Bureau (SPIB), Standard Grading Rules for Southern Pine Lumber.

1.3 QUALITY ASSURANCE

A. Regulatory Requirements: Comply with requirements of authorities having jurisdiction and the building code referred to in Section 01 42 00, References, for size, spacing and attachment of wood members, unless more stringent requirements are shown or specified in the Contract Documents.

B. Certifications:
   1. Certificates of Grade: Where appearance of wood is important and grade marks will deface the Work, in lieu of grade markings on wood, submit certificates attesting that materials comply with grade requirements specified.

1.4 SUBMITTALS

A. Action Submittals; Submit the following:
   1. Shop Drawings:
      a. List of species and grade of lumber proposed for each use.
      b. Fastener schedule with location, size, material and type of each fastener to be used in the Work.

B. Informational Submittals: Submit the following:
   1. Certificates:
      a. Lumber treater's certification of compliance, in accordance with Paragraph 1.3.B.1 of this Section.
      b. Certificates of grade in accordance with Paragraph 1.3.B.2 of this Section.

1.5 DELIVERY, STORAGE AND HANDLING

A. Packing, Shipping, Handling, and Unloading:
   1. Deliver products to Site to ensure uninterrupted progress of the Work. Deliver anchorage products that are to be embedded in concrete or masonry in ample time to prevent delaying the Work.
   2. Comply with Section 01 65 00, Product Delivery Requirements.

B. Storage and Protection:
   1. Keep materials dry during delivery and storage.
   2. Keep materials off ground using pallets, platforms, or other appropriate supports. Protect materials from corrosion and deterioration. Stack lumber, and provide air circulation within stacks.
   3. Comply with Section 01 66 00, Product Storage and Handling Requirements.

PART 2 – PRODUCTS

2.1 MATERIALS

A. Lumber, General:
   1. Factory-mark each piece of lumber with type, grade, mill and grading agency. Surfaces that will be exposed to view shall not have grade marks or other types of identifying marks.
   2. Nominal sizes are shown or indicated, unless otherwise shown or indicated in the Contract Documents. Provide actual sizes as required by ALSC PS 20 for moisture content specified for each use.
      a. Provide dressed lumber, surfaced four sides (S4S), unless otherwise shown or specified.
      b. Provide seasoned lumber with 19 percent maximum moisture content at time of dressing.
   3. Provide the following grade and species:
      a. Construction Grade, for material up to and including four-inch wide.
      b. No. 2 or better for material greater than four-inch wide up to and including 12-inch wide.
      c. Southern Pine, SPIB.
   4. Lumber for Protection and Temporary Support: Size and grades to conform to Laws and Regulations, including OSHA.

B. Fasteners and Anchorages:
   1. Fasteners exposed to the weather as well as fasteners embedded in, or in contact with, preservative treated wood shall be hot-dip galvanized.
   2. Common wire nails shall conform to ASTM F1667.
   3. Wood screws shall conform to ASME B18.6.1.
   4. Lag screws and lag bolts shall conform to ASME B18.2.1.
   5. Anchorage devices shall conform to Section 05 05 33, Anchor Systems.

PART 3 – EXECUTION

3.1 INSPECTION

A. Examine substrates and supporting structure and conditions under which miscellaneous rough carpentry Work will be installed and notify ENGINEER in writing of conditions detrimental to proper completion of the Work. Do not proceed with installation until unsatisfactory conditions are corrected.

3.2 INSTALLATION

A. Coordination: Fit miscellaneous rough carpentry Work to other Work and work under other contracts, as applicable, and scribe and cope as required for accurate fit. Correlate location of furring, nailers, blocking, grounds and similar supports to allow proper attachment of other construction.

B. General:

1. Discard units of material with defects that might impair quality of the Work, and units too small to fabricate the Work with minimum joints or optimum joint arrangement.
2. Set miscellaneous rough carpentry Work accurately to required levels and lines, with members plumb and true, accurately cut and fitted.
3. Securely attach miscellaneous rough carpentry Work to substrates by anchoring and fastening as shown and indicated in the Contract Documents. Countersink nail heads on exposed miscellaneous rough carpentry Work and fill holes. Make tight connections between members.
4. Install fasteners without splitting of wood, pre-drill as required and for masonry anchors fastened to wood stud wall framing.

C. Wood Grounds, Nailers, and Blocking:
1. Provide where shown or indicated, and where required for attachment of other construction. Form to shapes as shown or indicated and cut as required for true line and level of Work to be attached. Coordinate location with other work involved.
2. Attach substrates as required to support applied loading. Countersink bolts and nuts flush with surfaces, unless otherwise shown or indicated.
3. Provide permanent grounds of dressed, preservative-treated, key-bevelled lumber not less than 1.5-inch wide and of thickness required to bring face of ground to exact thickness of finish material involved. Remove temporary grounds when no longer required.

D. Plywood, General:
1. Install in accordance with the Contract Documents and requirements of authorities having jurisdiction.
2. Allow for installed clearances between individual plywood panels as specified by plywood manufacturer. Provide 1/4-inch space at panel edge joints and 1/8-inch space at panel end joints, unless otherwise recommended by manufacturer.
3. Install plywood with long dimension across supports.
4. Install roof sheathing using 8d helical or annular nails spaced fix inches at panel edges and 12 inches at intermediate framing.
5. Provide panel edge clips at unsupported edges of roof sheathing.

+ + END OF SECTION + +

SECTION 07 16 00

CAPILLARY WATERPROOFING

PART 1 - GENERAL

1.1 DESCRIPTION

A. Scope:
   1. Provide all labor, materials, equipment, and incidentals as shown, specified, and required to furnish and install capillary waterproofing.
   2. The extent of the capillary waterproofing Work is shown on Drawings.

B. Coordination:
   1. Review installation procedures under other Sections and coordinate the installation of items to be installed with or before the capillary waterproofing Work.
   2. Coordinate the placing of capillary waterproofing following manufacturer's recommendations for concrete treatment, finishes and curing, to produce maximum penetration and adhesion of capillary waterproofing.

1.2 REFERENCES

A. Standards referenced in this Section are:
   1. NSF/ANSI 61, Drinking Water System Components – Health Effects.

1.3 QUALITY ASSURANCE

A. Qualifications:
   1. Installer:
      a. Retain a single installer with experience in the application of capillary waterproofing who is a licensee of the capillary waterproofing manufacturer, or who can submit evidence of being acceptable to the manufacturer of the capillary waterproofing.
      b. Installer shall employ only tradesmen with specific skill and successful experience in the type of Work required.
      c. When requested by ENGINEER, submit name and qualifications of installer with the following information for not less than three successful, completed projects
         1) Names and telephone numbers of owner and architect or engineer responsible for each project.
         2) Approximate contract cost of capillary waterproofing work for which installer was responsible.
         3) Quantity, in square feet, of capillary waterproofing installed.

B. Component Supply and Compatibility:
   1. Obtain materials from only one manufacturer who will provide the services of a manufacturer's technical representative as specified.

1.4 SUBMITTALS

A. Action Submittals: Submit the following:
   1. Product Data:
      a. Manufacturer's specifications, installation instructions, and general recommendations for each type of capillary waterproofing product required. Include manufacturer's data substantiating that the materials comply with the requirements specified herein.

B. Informational Submittals: Submit the following:
   1. Certificates:
      a. Capillary waterproofing manufacturer's certification that installer received training in the proper installation of manufacturer's products required for the Work.
   2. Qualifications Statements: Submit qualifications for the following:
      a. Installer.

1.5 PRODUCT DELIVERY, STORAGE AND HANDLING

A. Delivery of Materials:
   1. Deliver materials in capillary waterproofing manufacturer's original unopened containers.
   2. Include the following information on the label:
      a. Name of material and supplier.
      b. Mixing instructions, shelf life and curing time when applicable.
   3. Deliver materials in sufficient quantity to allow continuity of the Work.

B. Storage of Materials:
   1. Store material in original, undamaged containers with manufacturer's labels and seals intact.
   2. Store materials in dry, enclosed areas, off the ground.
   3. Prevent damage to materials during storage.

C. Handling of Materials:
   1. Handle materials carefully to prevent inclusion of foreign materials.
   2. Do not open containers or mix components until necessary preparatory work has been completed.

1.6 JOB CONDITIONS

A. Environmental Conditions:
   1. Proceed with capillary waterproofing Work only when temperature and moisture conditions comply with the capillary waterproofing manufacturer's written recommendations and as specified herein.
   2. Surface and surrounding air temperature shall not be less than 35 degrees F for a minimum period of 48 hours before, during, and after the capillary waterproofing Work.
   3. Protect Work from precipitation, frost and direct sun.
   4. During hot weather use wet mats or constant mist water spray to prevent premature drying.
   5. Provide air circulation to assure setting of the capillary waterproofing.

B. Protection: Do not allow surfaces treated with capillary waterproofing to be exposed to aggressive water, chemicals or acids until capillary waterproofing has reached full strength.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Provide specially formulated, cementitious capillary waterproofing for "slurry coat" application technique, unless otherwise shown, consisting of a combination of chemicals, cement, and specially treated quartz, capable of extensive chemical penetration to produce crystalline growth which closes the natural concrete capillaries, providing dense, in-depth protection against moisture, chemical attack and liquid pressure.

B. Cementitious capillary waterproofing shall contain no iron oxide, calcium chloride, or organics.

C. Provide the manufacturer's complete system of waterproofing products as may be required for the conditions encountered, including construction joints.

D. Material shall be listed in NSF/ANSI 61.

2.2 MANUFACTURERS

A. Product and Manufacturer: Provide one of the following:
   1. Vandex Super by Vandex Sales & Services, Incorporated.
   2. Xypex by Xypex Chemical Corporation.
   3. Or equal.

2.3 MIXES

A. Mix following manufacturer's written instructions.

B. For construction joints and other conditions requiring special mixing, follow manufacturer's written instructions.

C. Do not add additional water to improve workability.

PART 3 - EXECUTION

3.1 INSPECTION

A. CONTRACTOR and his installer must examine the surfaces to receive the capillary waterproofing, and the conditions under which the capillary waterproofing Work is to be performed, and notify ENGINEER in writing of any conditions detrimental to the proper and timely completion of the Work and performance of the capillary waterproofing. Do not proceed with the capillary waterproofing Work until unsatisfactory conditions have been corrected in a manner acceptable to ENGINEER.

3.2 SUBSTRATE PREPARATION

A. Follow manufacturer's instructions for extremely high hydrostatic heads.

B. Provide rough wood float finish on concrete to expose capillaries.

C. Remove all laitance oil, dirt and other surface contamination.

D. Extremely smooth surfaces shall be acid etched.

E. Install seal strips 3/4 inch by 1-1/4 inch at all construction joints using laminating layers of special capillary waterproofing mortar, to achieve a watertight condition, as recommended by the manufacturer.

F. Fill all form tie holes, honeycombed areas, and cracks exceeding 0.1 inch, with combination of special capillary waterproofing mortars.

G. Do not use curing agents or hardeners on concrete to receive capillary waterproofing.

3.3 INSTALLATION

A. Do not apply capillary waterproofing until hydrostatic test results have been accepted by OWNER.

B. Provide the services of an on-site manufacturer's technical representative during the installation.

C. Using the "slurry coat" method of installation, apply capillary waterproofing at the rate of 1-1/2 pounds per square yard per coat following manufacturer's written instructions. Apply two coats for a total of three pounds per square yard.

D. Saturate surface with water and allow to dry until damp, but not wet to the touch.

E. Apply first coat by brush and while still damp fill in all cracks, joints and honeycombs with capillary waterproofing in layers not to exceed 1/2 inch.

F. While first coat is still damp, apply second coat. Remoisten if first coat dries before application of second coat.

G. Moisture cure all capillary waterproofing for a minimum period of two days, starting with a fine water fog spraying the day following completion of the application unless other recommendations are made by the manufacturer or because of weather conditions specified herein.

H. Allow 14 days for curing.

3.4 ADJUSTMENT AND CLEANING

A. Correct all leaks in the completed Work following written recommendations of capillary waterproofing manufacturer at no additional cost to the Owner.

B. Do not allow construction traffic on concrete slabs for 48 hours after application.

C. Protect from heavy construction traffic for seven days after installation.

D. Protect capillary waterproofing Work from freezing for seven days after installation.

E. Protect capillary waterproofing from damage until Final Acceptance by Owner.

3.5 INSPECTION AND ACCEPTANCE

A. Certify that the completed capillary waterproofing Work is in accordance with the Specifications and is watertight at the time of Final Acceptance.

++ END OF SECTION ++

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SECTION 07 22 16

ROOF BOARD INSULATION

PART 1 - GENERAL

1.1 DESCRIPTION

A. Scope:
   1. CONTRACTOR shall provide all labor, materials, tools, equipment and incidentals as shown, specified and required to furnish and install all roof board insulation.
   2. Extent of each type of roof board insulation is shown on Drawings.
   3. Types of products required include the following:
      a. Extruded, pentane isomer blown, polyisocyanurate rigid board-type insulation.
      b. Miscellaneous materials and accessories.

B. Coordination:
   1. Review installation procedures under other Sections and coordinate the installation of items that must be installed with the roof board insulation Work.
   2. All framing for openings, edge angles, nailers, curbs and other items shall be in place before start of roof board insulation Work.
   3. Field-verify location of all roof penetrations, drain locations, and deck deflections.

C. Related Sections:
   1. Section 06 10 53, Miscellaneous Rough Carpentry.
   2. Section 07 55 52, Modified Bituminous Protected Membrane Roofing.

1.2 REFERENCES

A. Standards referenced in this Section are listed below:
   1. American Society for Testing and Materials, (ASTM).
      a. ASTM C 518, Test Method for Steady-State Thermal Transmission Properties by Means of Heat Flow Meter Apparatus.
      b. ASTM C 1289, Specification for Faced Rigid Cellular Polyisocyanurate Thermal Insulation Board.
      c. ASTM D 1621, Test Method for Compressive Properties of Rigid Cellular Plastics.
      d. ASTM E 84, Test Method for Surface Burning Characteristics of Building Materials.
      e. ASTM E 96, Test Methods for Water Vapor Transmission of Materials.
   2. Factory Mutual, (FM).

a. FM Publication, Loss Prevention Data for Roofing Contractors, 1-29, Above-Deck Roof Components.
b. FM Publication, Approval Guide.

3. Underwriters Laboratories, (UL).
   a. UL Building Materials Directory.

1.3 QUALITY ASSURANCE

A. Installer's Qualifications:
   1. Roof board insulation Work shall be performed by the installer of the associated roofing for undivided responsibility.

B. Source Quality Control:
   1. Obtain extruded polyiscoyanurate rigid board-type insulation from manufacturers who manufacture specified insulation using a blowing agent containing no chlorine-based compounds.
   2. Engage a single manufacturer for each type of roofing insulation who shall provide the services of a technical representative to assist CONTRACTOR and ENGINEER by providing technical opinions on the adequacy of materials and methods of installation based on Shop Drawings approved by ENGINEER.
   3. Provide such services during the time of delivery, storage, handling and installation of all roofing insulation.
   4. The thicknesses shown are based on the thermal conductivity, k-value at 75°F specified for each material. Thicknesses of roof board insulation materials submitted by CONTRACTOR as "or equal" to specified materials shall have their thicknesses adjusted to provide the same thermal resistance as materials specified.

C. Requirements of Regulatory Agencies: Comply with fire-resistance ratings as required by governing authorities and building codes, and complies with the following roof board insulation requirements:
   1. Underwriters Laboratories requirements for roof deck constructions which are rated "UL Class A".
   2. Factory Mutual requirements for "Class 1-90" rated construction, for wind resistance.

1.4 SUBMITTALS

A. Action Submittals: Submit the following:
   1. Samples:
      a. Each fastener to be used in the Work.
      b. 12-inch by 12-inch sample of insulation system.
   2. Shop Drawings:
      a. Field verified locations of all roof penetrations, drain locations, and deck deflections.

b. Complete layout of all roof board insulation showing sizes, placement, number of courses and methods of fastening. Include statement that fastening method, location and density of fasteners have been approved by roof membrane manufacturer and comply with wind uplift requirements specified.
c. Weights of all equipment to be used on roof.
d. All required roof board insulation details approved by the roof board insulation manufacturer and the manufacturer of the respective roofing systems.

3. Product Data:
   a. Manufacturer's specifications and installation instructions for each type of roof board insulation required. Include data substantiating that the materials comply with specified requirements.

B. Informational Submittals: Submit the following
   1. Certificates:
      a. Installer's qualifications.

1.5 DELIVERY, STORAGE AND HANDLING

A. Delivery of Materials:
   1. Do not deliver insulation materials to the Site before time of installation.
   2. Deliver materials in manufacturer's original, undamaged packages or acceptable bulk containers.

B. Storage of Materials:
   1. Do not allow insulation materials to become wet or soiled, or covered with ice or snow.
   2. Protect plastic insulation from exposure to sunlight.
   3. Protect plastic insulation against ignition.
   4. Store packaged materials to protect them from the weather and physical damage.

C. Handling of Materials:
   1. Comply with manufacturer's recommendations for handling, storage and protection.

1.6 JOB CONDITIONS

A. Pre-Roofing Conference: Provide both a representative of the composite roof board insulation system manufacturer and the foreman of the installer who will actually work on this Project at the Pre-Roofing Conference specified in Section 07 55 52, Modified Bituminous Protected Membrane Roofing.

B. Environmental Requirements:
   1. Do not install roof board insulation when weather conditions are such that the deck is not completely dry, there is ice or snow on the deck, or where there is no

assurance that the roof board insulation can be completely protected from the weather by the end of the day's Work.

B. Protection:
   1. Do not overload the building structure with the weight of stored materials or use of equipment.
   2. Install temporary water cut-offs at the end of each day's Work to protect the roof board insulation. Remove the temporary water cut-offs upon resumption of the Work.

1.7 SEQUENCING

A. Proceed with and complete the Work only when materials, equipment and tradesmen required for the installation of the roofing membrane over the roof board insulation are at the Site and are ready to follow with this Work immediately (same day) after the roof board insulation Work.

B. Proceed with and complete the Work only when materials, equipment and tradesmen required for the installation of the roofing membrane over the insulation are at the Site; are installing the vapor barrier, and are ready to follow with this Work immediately (same day) behind the roof board insulation Work.

C. Do not install any more rigid board-type roof board insulation each day than can be covered with complete roofing system by the end of that working day.

1.8 SUBSTITUTIONS

A. Manufacturer of the primary roofing membrane systems shall be a manufacturer who finds the generic types of insulation specified herein as acceptable and bondable if installed according to the roofing manufacturer's standards for complete product and performance responsibility.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Extruded Polyisocyanurate Rigid Board Roof board insulation:
   1. Rigid, rectangular boards of extruded closed-cell polyisocyanurate complying with ASTM C 1289, Type II, with low water vapor permeability and laminated to heavy black (non-asphaltic) fiber-reinforced felt facers with one side of board containing perforated facers and the other side containing non-perforated facers.
   2. Provide a blowing agent with zero ozone depletion potential, such as pentane.
   3. Physical Properties: Provide the following:
      a. Minimum Compressive Strength, (at 10 percent deformation), ASTM D 1621: 25 psi minimum.

b. Flame Spread, ASTM E 108: Class A.
c. Smoke Development, ASTM E 84: 120 maximum.
d. Vapor Transmission, ASTM E 96: 0.8 perms/inch.
e. Thermal Resistance, ASTM C 518: 7/inch.
f. Maximum Water Absorption, ASTM C 209: 0.10 percent by volume.

4. Size: 48-inches by 96 inches by 2-inch thick.
5. Number of Layers: As required by thickness of roof board insulation shown.
6. Products and Manufacturers: Provide one of the following:
   a. ACUltra (Pentane Blown) Hydrocarbon ACFoam - II by Atlas Roofing Corporation.
   b. Or equal.

B. Miscellaneous Materials:
   1. Adhesive for Bonding Insulation: The type recommended by the roof board insulation manufacturer, and complying with fire-resistance requirements.
   2. Mechanical Anchors: The type recommended by the roof board insulation manufacturer for the type of deck used, and complying with fire and insurance rating requirements.
   3. Mastic Sealer: Type recommended by roof board insulation manufacturer for bonding edge joints between units and filling voids.

PART 3 - EXECUTION

3.1 INSPECTION

A. CONTRACTOR and installer shall examine the substrate and the conditions under which the roof board insulation Work is to be performed, and notify ENGINEER, in writing, of any unsatisfactory conditions. Do not proceed with the roof board insulation Work until unsatisfactory conditions have been corrected in a manner acceptable to ENGINEER.

B. Commencement of the Work shall be understood by ENGINEER to mean that all conditions are acceptable to the manufacturer's technical representative, CONTRACTOR and installer to provide acceptable Work under this Contract.

3.2 PREPARATION

A. Verify that vapor barrier has been installed on decks, with all joints and penetrations in the vapor barrier sealed using techniques recommended by the vapor barrier manufacturer to retain full perm rating of the vapor barrier.

3.3 INSTALLATION

A. General:

1. Comply with manufacturer's instructions for the particular conditions of installation in each case. If printed instructions are not available or do not apply to Site conditions, consult manufacturer's technical representative for specific recommendations before proceeding. Incorporate recommendations into the Work only as approved by ENGINEER. Record all such discussions and the basis for discussions in Job Conditions Report.
2. Coordinate heights of wood blocking to provide flush transition between roof board insulation and perimeter wood blocking.
3. Extend roof board insulation full thickness as shown over entire surface to be insulated.
4. Cut and fit tightly around obstructions, and fill voids with roof board insulation.

B. Board-Type Roof board insulation Units: Install rigid board-type roof board insulation according to FM 1-29 Wind Storm Resistance Classification specified, and as follows:
1. Install wood nailers as required by roofing membrane manufacturer.
2. Prime surface of concrete deck with asphalt primer at the rate of 3/4 gallons per 100 square feet, unless greater weight is required by roofing membrane system manufacturer, and allow primer to dry. Set each layer of roof board insulation in a solid mopping of hot roofing asphalt.
3. Apply two courses of roof board insulation to make up the total required thickness under roofing.
4 Install rigid board-type roof board insulation to form a continuous, uninterrupted plane between metal purlins installed perpendicularly to slope of metal deck, with all roof board insulation boards tightly butted together. Align top of roof board insulation boards flush with top surface of metal purlins or as shown for ventilated metal roof assemblies.
5. Stagger the short-side edges of roof board insulation board in one direction with the two opposite sides of each roof board insulation board continuously supported on steel deck ribs, as close as possible to the center of the rib as practical, and with a minimum bearing width of 1-inch. Trim board edges if they veer off the rib center. Stagger joints in each succeeding layer from joints of previous layer a minimum of 6-inches in each direction.
6. Coat edges of closed-cell (non-breathing) units with either adhesive or mastic sealer, and shove into place against installed units so that joints are filled and sealed.
7. Extend roof board insulation full thickness as shown over entire surface of roofs.

3.4 PERFORMANCE

A. Roof board insulation Work shall withstand the uplift forces of wind, as defined by the roofing guarantee.

B. Failures of the roof board insulation Work in bond or anchorage to the substrate, or between courses of roof board insulation, or within the roof board insulation, will be considered failures of materials or workmanship under the Roofing Guarantee.

3.5 FIELD QUALITY CONTROL

A. Test the substrate for moisture content, by suitable means, wherever there is a possibility that exposed substrate has acquired moisture in excess of the maximum content for optimum application of the insulation, as determined by the manufacturer.

3.6 PROTECTION

A. Do not permit construction traffic over completed insulation Work, except as required for roofing.

B. Protect roof board insulation Work from exposure to moisture, damage and deterioration, primarily by prompt installation of roofing Work to be placed over the roof board insulation.

3.7 INSPECTION AND ACCEPTANCE

A. Roof board insulation which has become wet, damaged, or deteriorated, as determined by ENGINEER, shall be promptly removed from the Site, even if already installed.

B. Correct all improperly sloped, chipped, cracked, improperly set, ridged or rough areas in the roof board insulation to provide substrate acceptable to roofing manufacturer and ENGINEER.

C. Final acceptance will be contingent upon the receipt by ENGINEER of a Job Conditions Report certifying conformance of the Work with the requirements of this Section and which includes all information requested by these Specifications.

++ END OF SECTION ++

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SECTION 07 55 52

MODIFIED BITUMINOUS MEMBRANE ROOFING

PART 1 - GENERAL

1.1 DESCRIPTION

A. Scope:
   1. CONTRACTOR shall provide all labor, materials, equipment and incidentals required to furnish and install modified bituminous membrane roofing with manufacturer's standard Thirty year warranty and CONTRACTOR'S two year roofing guarantee as shown and specified.
   2. The extent of modified bituminous membrane roofing is shown and includes walkway protection course and other items, if any, embedded in the Work, as specified in this Section.

B. Coordination:
   1. Review installation procedures under other Sections and coordinate the installation of items that must be installed with the modified bituminous protected membrane roofing Work.
   2. Coordinate the installation of roof insulation and associated work so as to provide a complete system complying with the combined recommendations of manufacturers and installers involved in the Work.

C. Related Sections:
   1. Section 06 10 53, Miscellaneous Rough Carpentry.
   2. Section 07 22 16, Roof Board Insulation.
   3. Section 07 62 00, Sheet Metal Flashing and Trim.

1.2 REFERENCES

A. Standards referenced in this Section are listed below:
   1. American Society for Testing and Materials, (ASTM).
      a. ASTM D 41, Specification for Asphalt Primer Used in Roofing, Dampproofing and Waterproofing.
      b. ASTM D 312, Specification for Asphalt Used in Roofing.
      c. ASTM D 6163, Specification for Styrene-Butadiene-Styrene (SBS) Modified Bituminous Sheet Materials using a Glass Fiber Reinforcements.
      d. ASTM E 96, Test Methods for Water Vapor Transmission of Materials.
   2. American Wood Preservers Bureau, (AWBP).
      a. AWPB Standard LP-2, Pressure Treated with Water-Borne Preservatives, Above Ground Use.
   3. Factory Mutual, (FM).

a. FM, Approval Guide.
4. National Roofing Contractors Association, (NRCA).
   a. NRCA, Roofing and Water Proofing Manual.
   b. NRCA, Roofing Materials Guide.
5. Underwriters Laboratories, Incorporated, (UL).
   a. UL, Building Materials Directory.
6. Kentucky Building Code, (KBC).

1.3 QUALITY ASSURANCE

A. Installer's Qualifications:
   1. Engage a single installer skilled, trained and with successful experience in the installation of modified bituminous membrane roofing systems, who is a recognized roofing installer with specific skill and successful experience in the type of roofing specified, 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 ENGINEER along with the following information on a minimum of three successful projects:
      a. Names and telephone numbers of owners, architects or engineers responsible for projects.
      b. Approximate contract cost of the modified bituminous membrane roofing system.
      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 manufacturer to ENGINEER.

B. Manufacturer's Field Reports: Submit the following reports directly to the project construction manager, with copy to others as requested.
   1. Inspector Requirements & Qualifications: Engage an experienced technical inspector, to perform daily job monitoring for this project. Inspector shall be specialized in inspecting roofing similar to that required for this Project; must have a minimum of five years experience providing roof construction monitoring and shall have no manufacturer sales responsibilities; must be full time employee of the roofing system manufacturer to daily inspect the manufacturer's project a minimum of four hours per work day and provide daily written reports to the Owner Representatives. The approved inspector must be certified as a Registered Roof Observer by the Roof Consultants Institute.
      a. Preparatory inspection.
      b. Initial inspection.
      c. Daily inspections.
      d. Final inspection.

C. Component Supply and Compatibility:

1. Obtain all roofing system components including but not limited to base sheet fasteners, insulation fasteners and adhesives, felts and adhesives, base flashing, adhesives, coatings, perimeter edge systems, and all miscellaneous adhesives from a single proposed roofing system manufacturer. All components shall be supplied and warranted by the proposed roof system manufacturer.

D. Requirements of Regulatory Agencies:
   1. Comply with applicable insurance rating bureau requirements as required by the Kentucky Building Code, unless more restrictive requirements are specified.
   2. Provide materials and roofing systems which have been tested, listed and labeled by Underwriter's Laboratories Incorporated for Class "A" rating, and bear the UL label on each package or are shipped to the project with a UL certificate of compliance.
   3. Provide materials and roofing systems which have been tested, listed and FM labeled for Class "I" rating.

E. Pre-Roofing Meeting:
   1. Prior to the installation of the roofing and associated Work, CONTRACTOR shall schedule and meet at the Site with the roofing installer, the installer of each component of associated Work, the installers of deck or substrate construction to receive roofing Work, the installers of other work in and around roofing which must follow the roofing Work, including mechanical work, if any, the ENGINEER and other representatives directly concerned with performance of the Work including where applicable, insurers, test agencies, product manufacturers, governing authorities having jurisdiction and the OWNER. Record the discussions of the Pre-Roofing Meeting and the decisions and agreements (or disagreements) and furnish a copy of the record to each party attending. Review foreseeable methods and procedures related to the roofing Work, including but not necessarily limited to the following:
      a. Review project requirements, including Drawings, Specifications and other Contract Documents.
      b. Review required submittal, 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 needed 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, environmental protection, health, safety, fire and similar considerations.
      h. Review procedures needed for protection of roofing during the remainder of the construction period.

2. Reconvene the meeting at the earliest opportunity if additional information must be developed in order to conclude the subjects under consideration.

1.4 SUBMITTALS

A. Action Submittals: Submit the following:
   1. Product Data:
      a. Copies of specifications, installation instructions and general recommendations from the roofing material's manufacturer, for each type of roofing product required. Include manufacturer's data substantiating that the materials comply with the requirements.

B. Informational Submittals: Submit the following:
   1. Source Quality Control Submittals:
      a. Research or evaluation reports indicating that materials specified meet required ASTM standards and building code requirements in addition to required FM and UL approvals.
   2. Qualifications Statements:
      a. Installer's qualifications.
      b. Manufacturer qualifications:
         a. Intent to warranty the system as specified and that proposed materials meet the specified standards.
         b. All materials to be supplied by a single source roof system manufacturer as a complete system.
         c. Construction observation: Submit letter from the manufacturer indicating who the technical inspector will be, experience qualifications, assurance of non-sales related functions and Registered Roof Observer certification along with copies of prior reports.
   3. Certificates:
      a. Copies of letter of final inspection, as specified.
   4. Site Quality Control:

C. Closeout Submittals: Submit the following:
   1. Warranty:
      a. Membrane manufacturer's representative shall inspect the installation of the modified bituminous membrane roofing system and upon approval provide a no-dollar-limit thirty year warranty. The warranty shall cover full roofing replacement, including materials and labor.
   1. Guarantee:
      a. Provide two year roofing guarantee covering the modified bituminous protected membrane roofing system Work indicated, signed by CONTRACTOR and installer.

1.5 DELIVERY, STORAGE AND HANDLING

A. Delivery of Materials:

1. Deliver materials in manufacturer's original, unopened containers and rolls with labels intact and legible.
2. Materials requiring fire resistance classification shall be delivered to the Site with labels attached and packaged as required by labeling service.
3. Deliver materials in sufficient quantity to allow continuity of the Work.

B. Storage of Materials:
1. Store roofing materials in a dry, well ventilated, weather tight place, and in a manner which will ensure that there is no possibility of significant moisture pick-up. Remove wet material from Site.
2. Store in a manner which complies with fire and safety regulations.
3. Store materials on clean raised platforms with weather protective covering when stored outdoors.

C. Handling of Materials:
1. Select and operate material handling equipment so as not to damage existing construction or applied roofing.

1.6 JOB CONDITIONS

A. Environmental Conditions:
1. Proceed with roofing and associated Work only when weather conditions will permit unrestricted use of materials and quality control of the Work being installed, complying with these Specification requirements and with the recommendations of the roofing materials manufacturers.
   a. Proceed only when CONTRACTOR and their installer are willing to guarantee the Work as required and without additional reservations and restrictions.
   b. Record decisions, conditions and agreements to proceed with the Work when weather conditions might be unfavorable. State the reasons for proceeding, with the names of the persons involved along with the changes, if any, or revisions, requirements or terms of the Contract.

B. Protection:
1. Provide continuous protection of materials against wetting and moisture absorption.
2. Protect materials against damage by construction traffic.

1.7 SCHEDULING

A. Proceed with the roofing and associated Work only after curbs, blocking, nailer strips, vents, drains and other projection through the substrate have been installed, and when the substrate construction and framing of openings are completed.

B. Proceed with and complete the Work only when materials, equipment and tradesmen required for the installation of the vapor barrier, roof insulation, cover boards and modified bituminous membrane roofing system are at the Site and are

ready to follow with the Work immediately (same day) for a complete modified bituminous protected membrane roofing system.

C. Phasing is not acceptable. Install all roofing and associated Work in a manner that will ensure a complete modified bituminous protected membrane roofing system at the end of each days' work. Do not advance the installation of any one material beyond that which is necessary for proper sequencing of the Work.

1.8 GUARANTEES

A. Provide a roofing guarantee in the form and content specified, covering the roofing and associated Work specified therein, signed by CONTRACTOR and their installer. Provide a two year roofing guarantee period, starting on the date of the OWNER'S Final Acceptance of the completed Work, stating that for the duration of the guarantee CONTRACTOR and installer shall be responsible to fix leaks, replace roofing system and roof insulation components damaged by moisture penetration and other defects caused by improper workmanship or the improper arrangement of the various system components.

B. Warranty:
   1. Modified bituminous membrane roofing system manufacturer's representative shall inspect the installation of the roofing assembly and upon approval provide a no-dollar-limit thirty year warranty. The warranty shall cover full roofing replacement, including materials and labor.

PART 2 - PRODUCTS

2.1 SYSTEM PERFORMANCE REQUIREMENTS

A. General: Install a watertight, modified bituminous membrane roofing and base flashing system with compatible components that will not permit the passage of liquid water and will withstand wind loads, thermally induced movement and exposure to weather without failure.
   1. Provide modified bituminous membrane roofing, base flashings and component materials that meet the requirements of FM 4450 and FM 4470 as part of a roofing system and that are listed in FM's Approval Guide for Class 1 or non-combustible construction, as applicable. Identify materials with FM markings.
   2. Provide materials and roofing systems which have been tested, listed and labeled by Underwriters Laboratories for Class A rating, and bear the UL label on each package of materials or are shipped to the Site with a UL Certificate of Compliance.
   3. Provide modified bituminous membrane roofing system with Fire/Windstorm classification of Class 1A-90 in compliance with FM standards.
   4. Provide a two-ply modified bitumen mineral surfaced roofing system, acceptable for use over manufacturer approved substrates, and on slopes-to-

drain up to 3-inches per foot. Approximate installed weight of modified bituminous protected membrane roofing is 255 lbs per square.

2.2 MATERIALS

A. Membrane:
   1. First Ply:
      a. POWERply HT Base by Tremco Incorporated.
      b. FlexBase E by The Garland Company.
   2. Finish Ply:
      a. POWERply Premium FR by Tremco Incorporated.
      b. StressPly E FR Mineral by The Garland Company.
   3. Products and Manufacturers: Provide one of the following:
      a. Two-ply SBS modified bitumen mineral surfaced roofing system by Tremco Incorporated.
      b. Two-ply SBS modified bitumen mineral surfaced roofing system by The Garland Company.
      c. Or equal.

B. Related Materials:
   1. Asphalt for Vapor retarder, Insulation, base sheet, and flashing:
      a. Asphalt shall be certified for full compliance with the requirements for Type III asphalt listed in Table 1, ASTM D 312.
         1) Tremco Premium III Asphalt
         2) Garland HPR All Temp Asphalt
      b. Each container shall indicate the equiviscous temperature (EVT), the finished blowing temperature (FBT), and the flash point.
   2. Cold Applied Modified Bitumen Cap Sheet Adhesive:
      a. Powerply Standard Cold Adhesive by Tremco.
      b. Weatherking Cold Adhesive by The Garland Company.
   3. Asphalt primer shall conform to ASTM D 41.
   4. Flashing Materials:
      a. Modified bitumen flashing sheet incorporating a fiberglass scrim/polyester mat composite reinforcement.
      b. Products and Manufacturers: Provide Two-ply flashing system:
         1) POWERply HT Base POWERply Plus HT FR_by Tremco Incorporated.
         2) Flexbase E Base and StressPly FR Mineral_by The Garland Company.
         3) Or equal.
   5. Mechanical Attachment:
      a. Corrosion-resistant fasteners in length and quantity as recommended and provided by the roof system manufacturer.

C. Walkway Pads:

1. Mineral surfaced modified bitumen cap sheet or mineral asphalt plank, ASTM D 517, minimum 1/2 -inch thick as recommended and provided by the rof system manufacturer.

D. Calking:
   1. Calking type and grade to provide a high performance, long-weathering seal for the surface mount counterflashing as recommended and provided by the roof system manufacturer.

E. Vapor Barrier for Structural Concrete Decks:
   1. Burmastic Composite Ply Base by Tremco.
   2. Tri Base by The Garland Company.

F. Mechanically Fastened Base Sheet for Gypsum Decks:
   1. Burmastic Composite Ply by Tremco.
   2. Tri Base by the Garland Company.

G. Base Sheet Fastener for Mechaincally fastened base:
   1. Light deck fasteners as recommended and provided by the roof system manufacturer.

H. Insulation:
   1. Insulation shall be compatible with the membrane, as recommended by the membrane manufacturer's printed instructions, and as specified in Section 07 22 16, Roof Board Insulation.

I. Cover Board: Provide a premium homogeneous, perlite based, 3/4-inch thick, or wood fiber base, ½-inch thick, roof insulation board in addition to roof insulation specified in Section 07720, Roof Insulation, for no-dollar-limit guaranteed construction, as required and provided by modified bituminous roof system manufacturer.

J. Wood Members, Units: Comply with requirements of Section 06 10 53, Miscellaneous Rough Carpentry, for nailers, cant strips and other wood members indicated as roofing system Work. Provide wood pressure treated with waterborne preservatives for above-ground use (American Wood Preservers Bureau Standard LP-2).

PART 3 - EXECUTION

3.1 INSPECTION

A. CONTRACTOR and installer must examine the substrate and the surface conditions to receive roofing and associated Work, and ascertain the conditions under which the Work will be performed, and notify the ENGINEER, in writing, of unsatisfactory conditions. Do not proceed with roofing and associated Work

until unsatisfactory conditions have been corrected in a manner acceptable to the ENGINEER.

3.2 PREPARATION

A. General: Comply with membrane manufacturer's instructions for preparation of substrate to receive roofing assembly.

B. Substrate must be smooth and free of ridges and depressions. Roofing Work shall not proceed until any unacceptable decking has been replaced.

C. Prime the substrate if recommended by the membrane manufacturer in accordance with the manufacturer's recommendations.

D. Install flashings, cant strips, nailers, vapor barrier, insulation, cover boards and similar items as recommended by the manufacturer of the roofing assembly.

E. Heat roofing asphalt and apply within plus or minus 25°F of equiviscous temperature, unless otherwise recommended by membrane manufacturer. Do not exceed roofing asphalt manufacturer's recommended temperature limits during roofing asphalt heating. Do not heat roofing asphalt within 25°F of flash point. Discard roofing asphalt maintained at a temperature exceeding 500°F for more than four hours. Keep kettle lid closed, unless adding roofing asphalt.

F. Prevent compounds from entering and clogging drains, conductors, and gutters, and from spilling or migrating onto surfaces of other work.

3.3 INSTALLATION

A. Vapor Barrier Installation:
   1. Beginning at the low point of the roof solid mop one ply of specified vapor barrier ply to the primed concrete deck surface, lapping sides a minimum of 3-inches and ends a minimum of 4-inches.

B. Mechanically Fastened Base Sheet Installation:
   1. Beginning at the low point of the roof and mechanically fasten one ply of specified mechanically attached base sheet to surface of gypsum decking, lapping sides a minimum of 3-inches and ends a minimum of 4-inche

C. Membrane Installation:
   1. Start installation only in the presence of manufacturer's technical representative.
   2. Beginning at the low point of the roof solid mop one ply of of specified base sheet in hot asphalt to the insulation surface, lapping sides a minimum of 3-inches and ends a minimum of 4-inches.
   3. Beginning at the low point fully adhere one ply of specified cap sheet in specified cold adhesive to the base ply, lapping sides and ends a minimum of 4-inches. Stagger laps between plies.

4. All layers of roofing shall be laid free of wrinkles, creases or fishmouths and shall be laid parallel to the slope of the deck.
5. Temporary seal all loose edges to prevent water from infiltrating under the new roof at the end of each days Work.

D. Flashing and Stripping Installation:
   1. Perimeter, curb, vents, expansion joints, drains and other details shall be flashed in accordance with the manufacturer's standard published details.
   2. Exercise extreme care to minimize possibility of damage to membrane.
      a. Base Flashing: Provide sufficiently wide to extend 4-inches out on the roof over the roofing (measured from the top edge of the cant strip). Prime masonry, concrete and plaster surfaces to receive the flashing with asphalt primer in accordance with manufacturer's recommendations and allow to dry before application. Mop concrete, masonry and plaster surfaces to receive flashing sheet with hot Type III asphalt. Embed the modified bitumen flashing sheet into the asphalt. End laps of base flashing shall not be less than 4-inches. . Strip in all vertical flashing laps and flashing toe with cold applied asphalt mastic and reinforcing mesh in three-course detail. Apply in accordance with the manufacturer's recommendations.
      b. Strip-In Flashing: Cover sheet metal flanges of pitch pockets, scuppers and flashings for vents and drains with one ply of specified base sheet and one ply of specified modified bitumen flashing sheet, laid in hot asphalt or cold applied asphalt mastic extending 4-inches beyond the edges of the underlying metal.
      c. Roof Drains: Set 30-inch by 30-inch metal flashing in bed of asphalt roofing cement on modified bitumen membrane roofing. Cover metal flashing with modified bitumen stripping extending a minimum of 4-inches beyond edge of metal flashing onto field of roof membrane. Clamp roof membrane, metal flashing and stripping into roof-drain

E. Walkway Pads:
   1. Traffic pads shall be installed in accordance with the manufacturer's recommendations and in areas as shown and at the following minimum locations.
      a. At perimeters of roof hatches.
      b. At perimeters of roof mounted mechanical and electrical equipment.
      c. At landings of roof access ladders.

F. Protect roofing and associated Work from damage until Final Completion by OWNER.

3.4 FIELD QUALITY CONTROL

A. Manufacturer's Construction Observation: Provide daily inspections and reporting in accordance with paragraph 1.7 C

B. Final Roof Inspection: Arrange for roofing system manufacturer's technical personnel to inspect roofing installation on completion and submit report to Owner's representative.
   1. Notify Owner's representative 48 hours in advance of date and time of inspection.

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

D. Additional testing and inspecting, at Contractor's expense, will be performed if needed, to determine compliance of replaced or additional work with specified requirements.

3.5 INSPECTION AND ACCEPTANCE

A. At the end of the construction period, or at a time when the remaining construction work will in no way affect or endanger the roofing and associated Work, make a final inspection of the Work and prepare a written report to the OWNER and the ENGINEER of deterioration, damage or deficiencies found in the Work.

B. Only the installer shall repair or replace deteriorated or defective Work.

C. Certify that the completed Work is in accordance with these Specifications and without damage or deterioration (except for normal weathering) at time of acceptance.

+ + END OF SECTION + +

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SECTION 07 62 00

SHEET METAL FLASHING AND TRIM

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:
   1. Formed Products:
      a. Formed roof drainage sheet metal fabrications.
      b. Formed low-slope roof sheet metal fabrications.

B. Related Sections:
   1. Division 6 Section 06 10 53, Miscellaneous Rough Carpentry for wood nailers, curbs, and blocking.
   2. Division 7 Section 07 51 23, Glass-fiber Reinforced Asphalt Emulsion Roofing for custom-formed sheet metal flashing and trim integral with sheet metal roofing.

1.3 PERFORMANCE REQUIREMENTS

A. General: Sheet metal flashing and trim assemblies as indicated shall withstand wind loads, structural movement, thermally induced movement, and exposure to weather without failure due to defective manufacture, fabrication, installation, or other defects in construction. Completed sheet metal flashing and trim shall not rattle, leak, or loosen, and shall remain watertight.

B. Thermal Movements: Provide sheet metal flashing and trim that allows for thermal movements from ambient and surface temperature changes.
   1. Temperature Change (Range): 120 deg F (67 deg C), ambient; 180 deg F (100 deg C), material surfaces.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product indicated. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for each manufactured product and accessory.

B. Shop Drawings: Show fabrication and installation layouts of sheet metal flashing and trim, including plans, elevations, expansion-joint locations, and keyed details. Distinguish between shop- and field-assembled work. Include the following:
   1. Identification of material, thickness, weight, and finish for each item and location in Project.
   2. Details for forming sheet metal flashing and trim, including profiles, shapes, seams, and dimensions.
   3. Details for joining, supporting, and securing sheet metal flashing and trim, including layout of fasteners, cleats, clips, and other attachments. Include pattern of seams.
   4. Details of termination points and assemblies, including fixed points.
   5. Details of expansion joints and expansion-joint covers, including showing direction of expansion and contraction.
   6. Details of edge conditions, including eaves, ridges, valleys, rakes, crickets, and counterflashings as applicable.
   7. Details of special conditions.
   8. Details of connections to adjoining work.
   9. Detail formed flashing and trim at a scale of not less than 3 inches per 12 inches (1:5).

C. Samples for Initial Selection: For each type of sheet metal flashing, trim, and accessory indicated with factory-applied color finishes involving color selection.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For qualified fabricator.

B. Warranty: Sample of special warranty.

1.6 CLOSEOUT SUBMITTALS

A. Maintenance Data: For sheet metal flashing, trim, and accessories to include in maintenance manuals.

1.7 QUALITY ASSURANCE

A. Fabricator Qualifications: Shop that employs skilled workers who custom fabricate sheet metal flashing and trim similar to that required for this Project and whose products have a record of successful in-service performance.

B. Sheet Metal Flashing and Trim Standard: Comply with SMACNA's "Architectural Sheet Metal Manual" unless more stringent requirements are specified or shown on Drawings.

C. Preinstallation Conference: Conduct conference at Project site.
   1. Meet with Owner, Architect, Owner's insurer if applicable, Installer, and installers whose work interfaces with or affects sheet metal flashing and trim

including installers of roofing materials, roof accessories, unit skylights, and roof-mounted equipment.
2. Review methods and procedures related to sheet metal flashing and trim.
3. Examine substrate conditions for compliance with requirements, including flatness and attachment to structural members.
4. Review special roof details, roof drainage, roof penetrations, equipment curbs, and condition of other construction that will affect sheet metal flashing.
5. Document proceedings, including corrective measures and actions required, and furnish copy of record to each participant.

1.8 DELIVERY, STORAGE, AND HANDLING

A. Do not store sheet metal flashing and trim materials in contact with other materials that might cause staining, denting, or other surface damage. Store sheet metal flashing and trim materials away from uncured concrete and masonry.

B. Protect strippable protective covering on sheet metal flashing and trim from exposure to sunlight and high humidity, except to the extent necessary for the period of sheet metal flashing and trim installation.

1.9 WARRANTY

A. Special Warranty on Finishes: Manufacturer's standard form in which manufacturer agrees to repair finish or replace sheet metal flashing and trim that shows evidence of deterioration of factory-applied finishes within specified warranty period.
   1. Exposed Panel Finish: Deterioration includes, but is not limited to, the following:
      a. Color fading more than 5 Hunter units when tested according to ASTM D 2244.
      b. Chalking in excess of a No. 8 rating when tested according to ASTM D 4214.
      c. Cracking, checking, peeling, or failure of paint to adhere to bare metal.
   2. Finish Warranty Period: (20) twenty years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 SHEET METALS

A. General: Protect mechanical and other finishes on exposed surfaces from damage by applying a strippable, temporary protective film before shipping.

   1. Exposed Coil-Coated Finishes:

a. Two-Coat Fluoropolymer: AAMA 620. Fluoropolymer finish containing not less than 70 percent PVDF resin by weight in color coat. Prepare, pretreat, and apply coating to exposed metal surfaces to comply with coating and resin manufacturers' written instructions.

2. Color: As selected by Architect from manufacturer's full range.

3. Concealed Finish: Pretreat with manufacturer's standard white or light-colored acrylic or polyester backer finish, consisting of prime coat and wash coat with a minimum total dry film thickness of 0.5 mil (0.013 mm).

2.2 MISCELLANEOUS MATERIALS

A. General: Provide materials and types of fasteners, solder, welding rods, protective coatings, separators, sealants, and other miscellaneous items as required for complete sheet metal flashing and trim installation and recommended by manufacturer of primary sheet metal[or manufactured item] unless otherwise indicated.

B. Fasteners: Wood screws, annular threaded nails, self-tapping screws, self-locking rivets and bolts, and other suitable fasteners designed to withstand design loads and recommended by manufacturer of primary sheet metal[or manufactured item].

1. General: Blind fasteners or self-drilling screws, gasketed, with hex-washer head.
   a. Exposed Fasteners: Heads matching color of sheet metal using plastic caps or factory-applied coating.
   b. Blind Fasteners: High-strength aluminum or stainless-steel rivets suitable for metal being fastened.
   c. Gutter Straps: Same material as gutter; with fasteners matching internal gutter width.

C. Sealant Tape: Pressure-sensitive, 100 percent solids, gray polyisobutylene compound sealant tape with release-paper backing. Provide permanently elastic, nonsag, nontoxic, nonstaining tape 1/2 inch (13 mm) wide and 1/8 inch (3 mm) thick.

D. Elastomeric Sealant: ASTM C 920, elastomeric [polyurethane] [polysulfide] [silicone] polymer sealant; low modulus; of type, grade, class, and use classifications required to seal joints in sheet metal flashing and trim and remain watertight.

E. Butyl Sealant: ASTM C 1311, single-component, solvent-release butyl rubber sealant; polyisobutylene plasticized; heavy bodied for hooked-type expansion joints with limited movement.

F. Epoxy Seam Sealer: Two-part, noncorrosive, aluminum seam-cementing compound, recommended by aluminum manufacturer for exterior nonmoving joints, including riveted joints.

2.3 FABRICATION, GENERAL

A. General: Custom fabricate sheet metal flashing and trim to comply with recommendations in SMACNA's "Architectural Sheet Metal Manual" that apply to design, dimensions, geometry, metal thickness, and other characteristics of item indicated. Fabricate items at the shop to greatest extent possible.
   1. Fabricate sheet metal flashing and trim in thickness or weight needed to comply with performance requirements, but not less than that specified for each application and metal.
   2. Obtain field measurements for accurate fit before shop fabrication.
   3. Form sheet metal flashing and trim without excessive oil canning, buckling, and tool marks and true to line and levels indicated, with exposed edges folded back to form hems.
   4. Conceal fasteners and expansion provisions where possible. Exposed fasteners are not allowed on faces exposed to view.

B. Fabrication Tolerances: Fabricate sheet metal flashing and trim that is capable of installation to a tolerance of 1/4 inch in 20 feet (6 mm in 6 m) on slope and location lines as indicated and within 1/8-inch (3-mm) offset of adjoining faces and of alignment of matching profiles.

C. Fabrication Tolerances: Fabricate sheet metal flashing and trim that is capable of installation to tolerances specified in MCA's "Guide Specification for Residential Metal Roofing."

D. Sealed Joints: Form nonexpansion but movable joints in metal to accommodate elastomeric sealant.

E. Expansion Provisions: Where lapped expansion provisions cannot be used, form expansion joints of intermeshing hooked flanges, not less than 1 inch (25 mm) deep, filled with butyl sealant concealed within joints.

F. Fabricate cleats and attachment devices from same material as accessory being anchored or from compatible, noncorrosive metal.

G. Fabricate cleats and attachment devices of sizes as recommended by SMACNA's "Architectural Sheet Metal Manual"[and by FMG Loss Prevention Data Sheet 1-49] for application, but not less than thickness of metal being secured.

H. Seams: Fabricate nonmoving seams with flat-lock seams. Tin edges to be seamed, form seams, and solder.

I. Seams: Fabricate nonmoving seams with flat-lock seams. Form seams and seal with elastomeric sealant unless otherwise recommended by sealant manufacturer for intended use.[Rivet joints where necessary for strength.]

J. Seams for Aluminum: Fabricate nonmoving seams with flat-lock seams. Form seams and seal with epoxy seam sealer.[Rivet joints where necessary for strength.]

K. Do not use graphite pencils to mark metal surfaces.

2.4 LOW-SLOPE ROOF SHEET METAL FABRICATIONS

A. Roof-Edge Flashing / Drip Edge: Fabricate in minimum 96-inch- (2400-mm-) long, but not exceeding 10-foot- (3-m-) long, sections. Furnish with 6-inch- (150-mm-) wide, joint cover plates.
   1. Joint Style: Lap, 4 inches (100 mm) wide.
   2. Fabricate from the following materials:
      a. Galvanized Steel: 0.028 inch (0.71 mm) thick.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates, areas, and conditions, with Installer present, to verify actual locations, dimensions and other conditions affecting performance of the Work.
   1. Verify compliance with requirements for installation tolerances of substrates.
   2. Verify that substrate is sound, dry, smooth, clean, sloped for drainage, and securely anchored.

B. For the record, prepare written report, endorsed by Installer, listing conditions detrimental to performance of the Work.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 UNDERLAYMENT INSTALLATION

A. General: Install underlayment as indicated on Drawings.

B. Polyethylene Sheet: Install polyethylene sheet with adhesive for anchorage to minimize use of mechanical fasteners under sheet metal flashing and trim. Apply in shingle fashion to shed water, with lapped and taped joints of not less than 2 inches (50 mm).

C. Felt Underlayment: Install felt underlayment with adhesive for temporary anchorage to minimize use of mechanical fasteners under sheet metal flashing and trim. Apply in shingle fashion to shed water, with lapped joints of not less than 2 inches (50 mm).

D. Self-Adhering Sheet Underlayment: Install self-adhering sheet underlayment, wrinkle free. Apply primer if required by underlayment manufacturer. Comply with temperature restrictions of underlayment manufacturer for installation; use primer rather than nails for installing underlayment at low temperatures. Apply in shingle fashion to shed water, with end laps of not less than 6 inches (150 mm) staggered 24 inches (600 mm) between courses. Overlap side edges not less than 3-1/2 inches (90 mm). Roll laps with roller. Cover underlayment within 14 days.

3.3 INSTALLATION, GENERAL

A. General: Anchor sheet metal flashing and trim and other components of the Work securely in place, with provisions for thermal and structural movement. Use fasteners, solder, welding rods, protective coatings, separators, sealants, and other miscellaneous items as required to complete sheet metal flashing and trim system.
   1. Install sheet metal flashing and trim true to line and levels indicated. Provide uniform, neat seams with minimum exposure of solder, welds, and sealant.
   2. Install sheet metal flashing and trim to fit substrates and to result in watertight performance. Verify shapes and dimensions of surfaces to be covered before fabricating sheet metal.
   3. Space cleats not more than 12 inches (300 mm) apart. Anchor each cleat with two fasteners. Bend tabs over fasteners.
   4. Install exposed sheet metal flashing and trim without excessive oil canning, buckling, and tool marks.
   5. Install sealant tape where indicated.
   6. Torch cutting of sheet metal flashing and trim is not permitted.
   7. Do not use graphite pencils to mark metal surfaces.

B. Metal Protection: Where dissimilar metals will contact each other or corrosive substrates, protect against galvanic action by painting contact surfaces with bituminous coating or by other permanent separation as recommended by SMACNA.
   1. Coat back side of [uncoated aluminum] [and] [stainless-steel] sheet metal flashing and trim with bituminous coating where flashing and trim will contact wood, ferrous metal, or cementitious construction.
   2. Underlayment: Where installing metal flashing directly on cementitious or wood substrates, install a course of felt underlayment and cover with a slip sheet or install a course of polyethylene sheet.

C. Expansion Provisions: Provide for thermal expansion of exposed flashing and trim. Space movement joints at a maximum of [10 feet (3 m)] <Insert dimension> with no joints allowed within 24 inches (600 mm) of corner or intersection. Where lapped expansion provisions cannot be used or would not be sufficiently watertight, form expansion joints of intermeshing hooked flanges, not less than 1 inch (25 mm) deep, filled with sealant concealed within joints.

D. Fastener Sizes: Use fasteners of sizes that will penetrate [wood sheathing not less than 1-1/4 inches (32 mm) for nails and not less than 3/4 inch (19 mm) for wood

screws] [metal decking not less than recommended by fastener manufacturer to achieve maximum pull-out resistance] <Insert size requirement>.

E. Seal joints as shown and as required for watertight construction.
   1. Where sealant-filled joints are used, embed hooked flanges of joint members not less than 1 inch (25 mm) into sealant. Form joints to completely conceal sealant. When ambient temperature at time of installation is moderate, between 40 and 70 deg F (4 and 21 deg C), set joint members for 50 percent movement each way. Adjust setting proportionately for installation at higher ambient temperatures. Do not install sealant-type joints at temperatures below 40 deg F (4 deg C).
   2. Prepare joints and apply sealants to comply with requirements in Division 7 Section 07 92 00, Joint Sealants.

F. Rivets: Rivet joints in uncoated aluminum where indicated and where necessary for strength.

3.4 ROOF DRAINAGE SYSTEM INSTALLATION

A. General: Install sheet metal roof drainage items to produce complete roof drainage system according to SMACNA recommendations and as indicated. Coordinate installation of roof perimeter flashing with installation of roof drainage system.

B. Hanging Gutters: Join sections with riveted and soldered joints or with lapped joints sealed with sealant. Provide for thermal expansion. Attach gutters at eave or fascia to firmly anchored gutter brackets or straps spaced not more than 36 inches (900 mm) apart. Provide end closures and seal watertight with sealant. Slope to downspouts.
   1. Fasten gutter spacers to front and back of gutter.
   2. Loosely lock straps to front gutter bead and anchor to roof deck.
   3. Anchor and loosely lock back edge of gutter to continuous [cleat] [eave or apron flashing].
   4. Anchor back of gutter that extends onto roof deck with cleats spaced not more than 24 inches (600 mm) apart.
   5. Install gutter with expansion joints at locations indicated, but not exceeding, 50 feet (15.24 m) apart. Install expansion-joint caps.

D. Downspouts: Join sections with 1-1/2-inch (38-mm) telescoping joints.
   1. Provide hangers with fasteners designed to hold downspouts securely to walls. Locate hangers at top and bottom and at approximately 60 inches (1500 mm) o.c. in between.
   2. Provide elbows at base of downspout to direct water away from building.
   3. Connect downspouts to underground drainage system indicated.

3.5 MISCELLANEOUS FLASHING INSTALLATION

A. Overhead-Piping Safety Pans: Suspend pans independent from structure above as indicated on Drawings. Pipe and install drain line to plumbing waste or drainage system.

B. Equipment Support Flashing: Coordinate installation of equipment support flashing with installation of roofing and equipment. Weld or seal flashing with elastomeric sealant to equipment support member.

3.6 ERECTION TOLERANCES

A. Installation Tolerances: Shim and align sheet metal flashing and trim within installed tolerance of 1/4 inch in 20 feet (6 mm in 6 m) on slope and location lines as indicated and within 1/8-inch (3-mm) offset of adjoining faces and of alignment of matching profiles.

B. Installation Tolerances: Shim and align sheet metal flashing and trim within installed tolerances specified in MCA's "Guide Specification for Residential Metal Roofing."

3.7 CLEANING AND PROTECTION

A. Clean exposed metal surfaces of substances that interfere with uniform oxidation and weathering.

B. Clean and neutralize flux materials. Clean off excess solder.

C. Clean off excess sealants.

D. Remove temporary protective coverings and strippable films as sheet metal flashing and trim are installed unless otherwise indicated in manufacturer's written installation instructions. On completion of installation, remove unused materials and clean finished surfaces. Maintain in a clean condition during construction.

E. Replace sheet metal flashing and trim that have been damaged or that have deteriorated beyond successful repair by finish touchup or similar minor repair procedures.

+ + END OF SECTION + +

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SECTION 07 72 00

ROOF ACCESSORIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:
   1. Roof Curbs.
   2. Equipment Support.

1.3 PERFORMANCE REQUIREMENTS

A. General Performance: Roof accessories shall withstand exposure to weather and resist thermally induced movement without failure, rattling, leaking, or fastener disengagement due to defective manufacture, fabrication, installation, or other defects in construction.

1.4 SUBMITTALS

A. Product Data: For each type of roof accessory indicated. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes.

B. Shop Drawings: For roof accessories. Include plans, elevations, keyed details, and attachments to other work. Indicate dimensions, loadings, and special conditions. Distinguish between plant- and field-assembled work.

1.5 COORDINATION

A. Coordinate layout and installation of roof accessories with roofing membrane and base flashing and interfacing and adjoining construction to provide a leakproof, weathertight, secure, and noncorrosive installation.

B. Coordinate dimensions with rough-in information or Shop Drawings of equipment to be supported.

PART 2 - PRODUCTS

2.1 METAL MATERIALS

A. Zinc-Coated (Galvanized) Steel Sheet: ASTM A 653/A 653M, G90 coating designation.

2.2 MISCELLANEOUS MATERIALS

A. General: Provide materials and types of fasteners, protective coatings, sealants, and other miscellaneous items required by manufacturer for a complete installation.

B. Fasteners: Roof accessory manufacturer's recommended fasteners suitable for application and metals being fastened.

C. Gaskets: Manufacturer's standard tubular or fingered design of neoprene, EPDM, PVC, or silicone or a flat design of foam rubber, sponge neoprene, or cork.

2.3 ROOF CURBS

A. Roof Pipe Curbs: Internally reinforced roof-pipe-curb units capable of supporting superimposed live and dead loads, including equipment loads and other construction indicated on Drawings; with welded or mechanically fastened and sealed corner joints and integrally formed deck-mounting flange at perimeter bottom.
   1. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
      a. AES Industries, Inc.
      b. Curbs Plus, Inc.
      c. Custom Solution Roof and Metal Products.
      d. Greenheck Fan Corporation.
      e. LM Curbs.
      f. Metallic Products Corp.
      g. Milcor Inc.; Commercial Products Group of Hart & Cooley, Inc.
      h. Pate Company (The).
      i. Roof Products, Inc.
      j. Safe Air of Illinois.
      k. Thybar Corporation.
      l. Vent Products Co., Inc.

B. Size: Coordinate dimensions with roughing-in information or Shop Drawings of equipment to be supported.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates, areas, and conditions, with Installer present, to verify actual locations, dimensions, and other conditions affecting performance of the Work.

B. Verify that substrate is sound, dry, smooth, clean, sloped for drainage, and securely anchored.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. General: Install roof accessories according to manufacturer's written instructions.
   1. Install roof accessories level, plumb, true to line and elevation, and without warping, jogs in alignment, excessive oil canning, buckling, or tool marks.
   2. Anchor roof accessories securely in place so they are capable of resisting indicated loads.
   3. Use fasteners, separators, sealants, and other miscellaneous items as required to complete installation of roof accessories and fit them to substrates.
   4. Install roof accessories to resist exposure to weather without failing, rattling, leaking, or loosening of fasteners and seals.

B. Metal Protection: Protect metals against galvanic action by separating dissimilar metals from contact with each other or with corrosive substrates by painting contact surfaces with bituminous coating or by other permanent separation as recommended by manufacturer.

C. Roof Curb Installation: Install each roof curb so top surface is level.

D. Equipment Support Installation: Install equipment supports so top surfaces are level with each other.

3.3 REPAIR AND CLEANING

A. Galvanized Surfaces: Clean field welds, bolted connections, and abraded areas and repair galvanizing according to ASTM A 780.

B. Touch up factory-primed surfaces with compatible primer ready for field painting according to Division 09 painting Sections.

C. Clean exposed surfaces according to manufacturer's written instructions.

D. Clean off excess sealants.

E. Replace roof accessories that have been damaged or that cannot be successfully repaired by finish touchup or similar minor repair procedures.

+ + END OF SECTION + +

SECTION 07 92 00

JOINT SEALANTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:
   1. Urethane joint sealants.

B. Related Sections:
   1. Division 4 Section 04 05 05, Masonry Construction, for masonry control and expansion joint fillers and gaskets.

1.3 PRECONSTRUCTION TESTING

A. Preconstruction Compatibility and Adhesion Testing: Submit to joint-sealant manufacturers, for testing indicated below, samples of materials that will contact or affect joint sealants.
   1. Use ASTM C 1087 manufacturer's standard test method to determine whether priming and other specific joint preparation techniques are required to obtain rapid, optimum adhesion of joint sealants to joint substrates.
   2. Submit not fewer than eight (8) pieces of each kind of material, including joint substrates, shims, joint-sealant backings, secondary seals, and miscellaneous materials.
   3. Schedule sufficient time for testing and analyzing results to prevent delaying the Work.
   4. For materials failing tests, obtain joint-sealant manufacturer's written instructions for corrective measures including use of specially formulated primers.
   5. Testing will not be required if joint-sealant manufacturers submit joint preparation data that are based on previous testing, not older than 24 months, of sealant products for adhesion to, and compatibility with, joint substrates and other materials matching those submitted.

B. Preconstruction Field-Adhesion Testing: Before installing sealants, field test their adhesion to Project joint substrates as follows:
   1. Locate test joints where indicated on Project or, if not indicated, as directed by Architect.
   2. Conduct field tests for each application indicated below:

a. Each kind of sealant and joint substrate indicated.

3. Notify Architect seven days in advance of dates and times when test joints will be erected.
4. Arrange for tests to take place with joint-sealant manufacturer's technical representative present.
   a. Test Method: Test joint sealants according to Method A, Field-Applied Sealant Joint Hand Pull Tab, in Appendix X1 in ASTM C 1193 or Method A, Tail Procedure, in ASTM C 1521.
      1) For joints with dissimilar substrates, verify adhesion to each substrate separately; extend cut along one side, verifying adhesion to opposite side. Repeat procedure for opposite side.
5. Report whether sealant failed to adhere to joint substrates or tore cohesively. Include data on pull distance used to test each kind of product and joint substrate. For sealants that fail adhesively, retest until satisfactory adhesion is obtained.
6. Evaluation of Preconstruction Field-Adhesion-Test Results: Sealants not evidencing adhesive failure from testing, in absence of other indications of noncompliance with requirements, will be considered satisfactory. Do not use sealants that fail to adhere to joint substrates during testing.

1.4 ACTION SUBMITTALS

A. Product Data: For each joint-sealant product indicated.

B. Samples for Initial Selection: Manufacturer's color charts consisting of strips of cured sealants showing the full range of colors available for each product exposed to view.

C. Samples for Verification: For each kind and color of joint sealant required, provide Samples with joint sealants in 1/2-inch- (13-mm-) wide joints formed between two 6-inch- (150-mm-) long strips of material matching the appearance of exposed surfaces adjacent to joint sealants.

D. Joint-Sealant Schedule: Include the following information:
   1. Joint-sealant application, joint location, and designation.
   2. Joint-sealant manufacturer and product name.
   3. Joint-sealant formulation.
   4. Joint-sealant color.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For qualified Installer.

B. Product Certificates: For each kind of joint sealant and accessory, from manufacturer.

C. Product Test Reports: Based on evaluation of comprehensive tests performed by a qualified testing agency, indicating that sealants comply with requirements.

D. Preconstruction Compatibility and Adhesion Test Reports: From sealant manufacturer, indicating the following:
   1. Materials forming joint substrates and joint-sealant backings have been tested for compatibility and adhesion with joint sealants.
   2. Interpretation of test results and written recommendations for primers and substrate preparation needed for adhesion.

E. Preconstruction Field-Adhesion Test Reports: Indicate which sealants and joint preparation methods resulted in optimum adhesion to joint substrates based on testing specified in "Preconstruction Testing" Article.

F. Field-Adhesion Test Reports: For each sealant application tested.

G. Warranties: Sample of special warranties.

1.6 QUALITY ASSURANCE

A. Installer Qualifications: Manufacturer's authorized representative who is trained and approved for installation of units required for this Project.

B. Source Limitations: Obtain each kind of joint sealant from single source from single manufacturer.

C. Product Testing: Test joint sealants using a qualified testing agency.
   1. Testing Agency Qualifications: An independent testing agency qualified according to ASTM C 1021 to conduct the testing indicated.
   2. Test according to SWRI's Sealant Validation Program for compliance with requirements specified by reference to ASTM C 920 for adhesion and cohesion under cyclic movement, adhesion-in-peel, and indentation hardness.

D. Mockups: Install sealant in mockups of assemblies specified in other Sections that are indicated to receive joint sealants specified in this Section. Use materials and installation methods specified in this Section.

E. Preinstallation Conference: Conduct conference at Project site.

1.7 PROJECT CONDITIONS

A. Do not proceed with installation of joint sealants under the following conditions:
   1. When ambient and substrate temperature conditions are outside limits permitted by joint-sealant manufacturer or are below 40 deg F (5 deg C).
   2. When joint substrates are wet.

3. Where joint widths are less than those allowed by joint-sealant manufacturer for applications indicated.
4. Where contaminants capable of interfering with adhesion have not yet been removed from joint substrates.

1.8 WARRANTY

A. Special Installer's Warranty: Manufacturer's standard form in which Installer agrees to repair or replace joint sealants that do not comply with performance and other requirements specified in this Section within specified warranty period.
   1. Warranty Period: (2) Two years from date of Substantial Completion.

B. Special Manufacturer's Warranty: Manufacturer's standard form in which joint-sealant manufacturer agrees to furnish joint sealants to repair or replace those that do not comply with performance and other requirements specified in this Section within specified warranty period.
   1. Warranty Period: (5) Five years from date of Substantial Completion.

C. Special warranties specified in this article exclude deterioration or failure of joint sealants from the following:
   1. Movement of the structure caused by structural settlement or errors attributable to design or construction resulting in stresses on the sealant exceeding sealant manufacturer's written specifications for sealant elongation and compression.
   2. Disintegration of joint substrates from natural causes exceeding design specifications.
   3. Mechanical damage caused by individuals, tools, or other outside agents.
   4. Changes in sealant appearance caused by accumulation of dirt or other atmospheric contaminants.

PART 2 - PRODUCTS

2.1 MATERIALS, GENERAL

A. Compatibility: Provide joint sealants, backings, and other related materials that are compatible with one another and with joint substrates under conditions of service and application, as demonstrated by joint-sealant manufacturer, based on testing and field experience.

B. VOC Content of Interior Sealants: Sealants and sealant primers used inside the weatherproofing system shall comply with the following limits for VOC content when calculated according to 40 CFR 59, Subpart D (EPA Method 24):
   1. Architectural Sealants: 250 g/L.
   2. Sealant Primers for Nonporous Substrates: 250 g/L.
   3. Sealant Primers for Porous Substrates: 775 g/L.

C. Provide colors selected by ENGINEER from calking and sealant manufacturer's standard and custom color charts. "Or equal" manufacturers shall provide same generic products and colors as available from manufacturers specified.

2.2 MATERIALS

A. Exterior and Interior Horizontal and Vertical Joints; Submerged and Intermittently Submerged in Potable Water or Water That Will be Treated to Become Potable:
   1. One-component Polyurethane Sealant:
      a. Products and Manufacturers: Provide one of the following:
         1) Sikaflex-1a by Sika Corporation.
         2) Or equal.
      b. One-component, moisture cured, gun grade, polyurethane sealant, complying with:
         1) FS TT-S-00230C, Type II, Class A; ASTM C920, Type S, Grade NS, Class 25.
         2) Adhesion-in-Peel, FS TT-S-00230C, ASTM C794 (minimum five pounds.): Glass, minimum 20 pounds per linear inch; Aluminum, minimum 20 pounds per linear inch; Concrete, minimum 20 pounds per linear inch.
         3) Hardness (Standard Conditions), ASTM D2240: 20 to 25 (Shore A).
         4) Stain and Color Change, FS TT-S-00227E and ASTM C510: No discoloration or stain.
         5) Accelerated Aging, ASTM C793: No change in sealant characteristics after 250 hours in weatherometer.
         6) Rheological Vertical Displacement at 120 degrees F, FS TT-S-00227E: No sag.
         7) VOC Content: 100 g/L, maximum.
         8) Listed in NSF/ANSI 61
   2. Two-component Polyurethane Sealant:
      a. Products and Manufacturers: Provide one of the following:
         1) Sikaflex- 2c NS by Sika Corporation.
         2) Or equal.
      b. Two-component, moisture cured, gun grade, polyurethane sealant, complying with:
         1) FS TT-S-00227E, Type II, Class A; ASTM C920, Type M, Grade NS, Class 25.
         2) Adhesion-in-Peel, FS TT-S-00227E, ASTM C794 (Minimum five pounds per linear inch with no adhesion failure): 18 pounds.
         3) Hardness (Standard Conditions), ASTM C661: 25 (Shore A).
         4) Stain and Color Change, FS TT-S-00227E and ASTM C510: No discoloration or stain.

5) Accelerated Aging, ASTM C793: No change in sealant characteristics after 250 hours in weatherometer.
6) Rheological Vertical Displacement at 120 degrees F, FS TT-S-00227E: No sag.
7) VOC Content: 220 g/L, maximum.
8) Listed in NSF/ANSI 61

B. Exterior and Interior Vertical Joints; Non-submerged:
1. Two-component Polyurethane Sealant:
a. Products and Manufacturers: Provide one of the following:
1) Sikaflex- 2c NS by Sika Corporation.
2) Dymeric 240 FC by Tremco Sealant/Waterproofing Division of RPM International, Inc.
3) Or equal.
b. Polyurethane based, two-component elastomeric sealant complying with:
1) FS TT-S-00227E: Type II (non-sag) Class A and ASTM C920, Type M, Grade NS, Class 25.
2) Adhesion-in-Peel, FS TT-S-00227E and ASTM C794: (Minimum five pounds per linear inch with no adhesion failure): 10 pounds.
3) Hardness (Standard Conditions), ASTM C661: 25 to 35 (Shore A).
4) Stain and color change, FS TT-S-00227E and ASTM C510: No discoloration or stain.
5) Accelerated Aging, ASTM C793: No change in sealant characteristics after 250 hours in weatherometer.
6) Rheological Vertical Displacement at 120 degrees F, FS TT-S-00227E: No sag.
7) VOC Content: 100 g/L, maximum.

C. Exterior and Interior Horizontal Joints; Non-submerged:
1. Two-component Polyurethane Sealant:
a. Products and Manufacturers: Provide one of the following:
1) Sikaflex- 2c SL by Sika Corporation.
2) THC/900 by Tremco Sealant/Waterproofing Division of RPM International, Inc.
3) Or equal.
b. Polyurethane based, two-component elastomeric, self-leveling sealant complying with the following:
1) FS TT-S-00227E, Type I (self-leveling) Class A. and ASTM C920, Type M, Grade P, Class 25
2) Water Immersion Bond, FS TT-S-00227E: Elongation of 50 percent with no adhesive failure.
3) Hardness (Standard Conditions), ASTM C661: 35 to 45.
4) Stain and Color Change, FS TT-S-00227E and ASTM C510: No discoloration or stain.

5) Accelerated Aging, ASTM C793: No change in sealant characteristics after 250 hours in weatherometer.
6) VOC Content: 165 g/L, maximum.

2.3 JOINT SEALANT BACKING

A. General: Provide sealant backings of material that are nonstaining; are compatible with joint substrates, sealants, primers, and other joint fillers; and are approved for applications indicated by sealant manufacturer based on field experience and laboratory testing.

B. Cylindrical Sealant Backings: ASTM C 1330, Type C (closed-cell material with a surface skin) and of size and density to control sealant depth and otherwise contribute to producing optimum sealant performance.

C. Bond-Breaker Tape: Polyethylene tape or other plastic tape recommended by sealant manufacturer for preventing sealant from adhering to rigid, inflexible joint-filler materials or joint surfaces at back of joint. Provide self-adhesive tape where applicable.

2.4 MISCELLANEOUS MATERIALS

A. Primer: Material recommended by joint-sealant manufacturer where required for adhesion of sealant to joint substrates indicated, as determined from preconstruction joint-sealant-substrate tests and field tests.

B. Cleaners for Nonporous Surfaces: Chemical cleaners acceptable to manufacturers of sealants and sealant backing materials, free of oily residues or other substances capable of staining or harming joint substrates and adjacent nonporous surfaces in any way, and formulated to promote optimum adhesion of sealants to joint substrates.

C. Masking Tape: Nonstaining, nonabsorbent material compatible with joint sealants and surfaces adjacent to joints.

D. Low-temperature Catalyst: As recommended by calking and sealant manufacturer.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine joints indicated to receive joint sealants, with Installer present, for compliance with requirements for joint configuration, installation tolerances, and other conditions affecting joint-sealant performance.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Surface Cleaning of Joints: Clean out joints immediately before installing joint sealants to comply with joint-sealant manufacturer's written instructions and the following requirements:
   1. Remove all foreign material from joint substrates that could interfere with adhesion of joint sealant, including dust, paints (except for permanent, protective coatings tested and approved for sealant adhesion and compatibility by sealant manufacturer), old joint sealants, oil, grease, waterproofing, water repellents, water, surface dirt, and frost.
   2. Clean porous joint substrate surfaces by brushing, grinding, mechanical abrading, or a combination of these methods to produce a clean, sound substrate capable of developing optimum bond with joint sealants. Remove loose particles remaining after cleaning operations above by vacuuming or blowing out joints with oil-free compressed air. Porous joint substrates include the following:
      a. Concrete.
      b. Masonry.
      c. Unglazed surfaces of ceramic tile.
      d. Exterior insulation and finish systems.
   3. Remove laitance and form-release agents from concrete.
   4. Clean nonporous joint substrate surfaces with chemical cleaners or other means that do not stain, harm substrates, or leave residues capable of interfering with adhesion of joint sealants. Nonporous joint substrates include the following:
      a. Metal.
      b. Glass.
      c. Porcelain enamel.
      d. Glazed surfaces of ceramic tile.

B. Joint Priming: Prime joint substrates where recommended by joint-sealant manufacturer or as indicated by preconstruction joint-sealant-substrate tests or prior experience. Apply primer to comply with joint-sealant manufacturer's written instructions. Confine primers to areas of joint-sealant bond; do not allow spillage or migration onto adjoining surfaces.

C. Masking Tape: Use masking tape where required to prevent contact of sealant or primer with adjoining surfaces that otherwise would be permanently stained or damaged by such contact or by cleaning methods required to remove sealant smears. Remove tape immediately after tooling without disturbing joint seal.

3.3 INSTALLATION OF JOINT SEALANTS

A. General: Comply with joint-sealant manufacturer's written installation instructions for products and applications indicated, unless more stringent requirements apply.

B. Sealant Installation Standard: Comply with recommendations in ASTM C 1193 for use of joint sealants as applicable to materials, applications, and conditions indicated.

C. Install sealant backings of kind indicated to support sealants during application and at position required to produce cross-sectional shapes and depths of installed sealants relative to joint widths that allow optimum sealant movement capability.
   1. Do not leave gaps between ends of sealant backings.
   2. Do not stretch, twist, puncture, or tear sealant backings.
   3. Remove absorbent sealant backings that have become wet before sealant application and replace them with dry materials.

D. Install bond-breaker tape behind sealants where sealant backings are not used between sealants and backs of joints.

E. Install sealants using proven techniques that comply with the following and at the same time backings are installed:
   1. Place sealants so they directly contact and fully wet joint substrates.
   2. Completely fill recesses in each joint configuration.
   3. Produce uniform, cross-sectional shapes and depths relative to joint widths that allow optimum sealant movement capability.

F. Tooling of Nonsag Sealants: Immediately after sealant application and before skinning or curing begins, tool sealants according to requirements specified in subparagraphs below to form smooth, uniform beads of configuration indicated; to eliminate air pockets; and to ensure contact and adhesion of sealant with sides of joint.
   1. Remove excess sealant from surfaces adjacent to joints.
   2. Use tooling agents that are approved in writing by sealant manufacturer and that do not discolor sealants or adjacent surfaces.
   3. Provide concave joint profile per Figure 8A in ASTM C 1193, unless otherwise indicated.
   4. Provide flush joint profile where indicated per Figure 8B in ASTM C 1193.
   5. Provide recessed joint configuration of recess depth and at locations indicated per Figure 8C in ASTM C 1193.
      a. Use masking tape to protect surfaces adjacent to recessed tooled joints.

G. Installation of Preformed Silicone-Sealant System: Comply with the following requirements:
   1. Apply masking tape to each side of joint, outside of area to be covered by sealant system.

2. Apply silicone sealant to each side of joint to produce a bead of size complying with preformed silicone-sealant system manufacturer's written instructions and covering a bonding area of not less than 3/8 inch (10 mm). Hold edge of sealant bead 1/4 inch (6 mm) inside masking tape.
3. Within 10 minutes of sealant application, press silicone extrusion into sealant to wet extrusion and substrate. Use a roller to apply consistent pressure and ensure uniform contact between sealant and both extrusion and substrate.
4. Complete installation of sealant system in horizontal joints before installing in vertical joints. Lap vertical joints over horizontal joints. At ends of joints, cut silicone extrusion with a razor knife.

H. Installation of Preformed Foam Sealants: Install each length of sealant immediately after removing protective wrapping. Do not pull or stretch material. Produce seal continuity at ends, turns, and intersections of joints. For applications at low ambient temperatures, apply heat to sealant in compliance with sealant manufacturer's written instructions.

I. Acoustical Sealant Installation: At sound-rated assemblies and elsewhere as indicated, seal construction at perimeters, behind control joints, and at openings and penetrations with a continuous bead of acoustical sealant. Install acoustical sealant at both faces of partitions at perimeters and through penetrations. Comply with ASTM C 919 and with manufacturer's written recommendations.

3.4 FIELD QUALITY CONTROL

A. Field-Adhesion Testing: Field test joint-sealant adhesion to joint substrates as follows:
   1. Extent of Testing: Test completed and cured sealant joints as follows:
      a. Perform (10) ten tests for the first for each kind of sealant and joint substrate.
   2. Test Method: Test joint sealants according to Method A, Field-Applied Sealant Joint Hand Pull Tab, in Appendix X1 in ASTM C 1193 or Method A, Tail Procedure, in ASTM C 1521.
      a. For joints with dissimilar substrates, verify adhesion to each substrate separately; extend cut along one side, verifying adhesion to opposite side. Repeat procedure for opposite side.
   3. Inspect tested joints and report on the following:
      a. Whether sealants filled joint cavities and are free of voids.
      b. Whether sealant dimensions and configurations comply with specified requirements.
      c. Whether sealants in joints connected to pulled-out portion failed to adhere to joint substrates or tore cohesively. Include data on pull distance used to test each kind of product and joint substrate. Compare these results to determine if adhesion passes sealant manufacturer's field-adhesion hand-pull test criteria.

4. Record test results in a field-adhesion-test log. Include dates when sealants were installed, names of persons who installed sealants, test dates, test locations, whether joints were primed, adhesion results and percent elongations, sealant fill, sealant configuration, and sealant dimensions.
5. Repair sealants pulled from test area by applying new sealants following same procedures used originally to seal joints. Ensure that original sealant surfaces are clean and that new sealant contacts original sealant.

B. Evaluation of Field-Adhesion Test Results: Sealants not evidencing adhesive failure from testing or noncompliance with other indicated requirements will be considered satisfactory. Remove sealants that fail to adhere to joint substrates during testing or to comply with other requirements. Retest failed applications until test results prove sealants comply with indicated requirements.

3.5 CLEANING

A. Clean off excess sealant or sealant smears adjacent to joints as the Work progresses by methods and with cleaning materials approved in writing by manufacturers of joint sealants and of products in which joints occur.

3.6 PROTECTION

A. Protect joint sealants during and after curing period from contact with contaminating substances and from damage resulting from construction operations or other causes so sealants are without deterioration or damage at time of Substantial Completion. If, despite such protection, damage or deterioration occurs, cut out and remove damaged or deteriorated joint sealants immediately so installations with repaired areas are indistinguishable from original work.

+ + END OF SECTION + +

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SECTION 08 11 00

HOLLOW METAL DOORS AND FRAMES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:
   1. Galvanized interior and exterior standard hollow metal doors and frames.

B. Related Sections:
   1. Division 8 Section 08 71 00, Door Hardware, for door hardware for hollow metal doors.
   2. Division 9 Section 09 91 00, Painting, for field painting hollow metal doors and frames.

1.3 DEFINITIONS

A. Minimum Thickness: Minimum thickness of base metal without coatings.

B. Standard Hollow Metal Work: Hollow metal work fabricated according to ANSI/SDI A250.8.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product indicated. Include construction details, material descriptions, core descriptions, fire-resistance rating and finishes.

B. Shop Drawings: Include the following:
   1. Elevations of each door design.
   2. Details of doors, including vertical and horizontal edge details and metal thicknesses.
   3. Frame details for each frame type, including dimensioned profiles and metal thicknesses.
   4. Locations of reinforcement and preparations for hardware.
   5. Details of each different wall opening condition.
   6. Details of anchorages, joints, field splices, and connections.
   7. Details of accessories.
   8. Details of moldings, removable stops, and glazing.

9. Details of conduit and preparations for power, signal, and control systems.

C. Samples for Initial Selection: For units with factory-applied color finishes.

D. Other Action Submittals:
   1. Schedule: Provide a schedule of hollow metal work prepared by or under the supervision of supplier, using same reference numbers for details and openings as those on Drawings. Coordinate with door hardware schedule.

1.5 INFORMATIONAL SUBMITTALS

A. Oversize Construction Certification: For assemblies required to be fire rated and exceeding limitations of labeled assemblies.

B. Product Test Reports: Based on evaluation of comprehensive tests performed by a qualified testing agency, for each type of hollow metal door and frame assembly.

1.6 QUALITY ASSURANCE

A. Source Limitations: Obtain hollow metal work from single source from single manufacturer.

B. Regulatory Requirements:
   1. Fire Resistance-Rated Assemblies: Wherever a fire resistance classification is shown or scheduled for hollow metal doors and frames (3-hour, 1 1/2-hour, and similar designations), provide fire resistance-rated hollow metal doors and frames tested as a fire door assembly, complete with type of fire door hardware to be used.
   2. Identify each fire-resistance-rated door and frame with recognized testing laboratory labels, indicating applicable fire-resistance-rating of both door and frame. Provide fire-resistance-rated doors and frames with metal labels permanently fastened to door and frame. Labels shall display all UL required information.
   3. Temperature Rise Rating: Wherever a temperature rise rating is required by the building code, provide doors for fire-resistance-ratings shown and in accordance with UL 10B.
      a. For a UL 3 hour (A) classification, provide doors with a temperature rise rating of not more than 250°F maximum to 30 minutes of exposure.
      b. For a UL 1 1/2-hour (B) classification, provide doors with a temperature rise rating of not more than 450°F or 650°F maximum to 30 minutes of exposure.

   4. Door and frame assemblies shall comply with NFPA 80, and as specified. Modify specified hollow metal door and frame system components to comply

with requirements of governing jurisdictions for fire-resistance-rated construction.

5. Oversize Assemblies: Wherever hollow metal assemblies are larger than size limitations established by ANSI/NFPA 252 and UL10B provide manufacturer's certification that assembly has been constructed with materials and methods equivalent to labeled construction.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Deliver hollow metal work palletized, wrapped, or crated to provide protection during transit and Project-site storage. Do not use nonvented plastic.
   1. Provide additional protection to prevent damage to finish of factory-finished units.

B. Deliver welded frames with two removable spreader bars across bottom of frames, tack welded to jambs and mullions.

C. Store hollow metal work under cover at Project site. Place in stacks of five units maximum in a vertical position with heads up, spaced by blocking, on minimum 4-inch- (102-mm-) high wood blocking. Do not store in a manner that traps excess humidity.
   1. Provide minimum 1/4-inch (6-mm) space between each stacked door to permit air circulation.

1.8 PROJECT CONDITIONS

A. Field Measurements: Verify actual dimensions of openings by field measurements before fabrication.

1.9 COORDINATION

A. Coordinate installation of anchorages for hollow metal frames. Furnish setting drawings, templates, and directions for installing anchorages, including sleeves, concrete inserts, anchor bolts, and items with integral anchors. Deliver such items to Project site in time for installation.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   1. Amweld Building Products, LLC.
   2. Benchmark; a division of Therma-Tru Corporation.

3. Ceco Door Products; an Assa Abloy Group company.
4. Curries Company; an Assa Abloy Group company.
5. Deansteel Manufacturing Company, Inc.
6. Firedoor Corporation.
7. Fleming Door Products Ltd.; an Assa Abloy Group company.
8. Habersham Metal Products Company.
9. Karpen Steel Custom Doors & Frames.
10. Kewanee Corporation (The).
11. Mesker Door Inc.
12. Pioneer Industries, Inc.
13. Security Metal Products Corp.
14. Steelcraft; an Ingersoll-Rand company.
15. Windsor Republic Doors.
16. Equivalent by other manufacturer.

2.2 MATERIALS

A. Cold-Rolled Steel Sheet: ASTM A 1008/A 1008M, Commercial Steel (CS), Type B; suitable for exposed applications.

B. Hot-Rolled Steel Sheet: ASTM A 1011/A 1011M, Commercial Steel (CS), Type B; free of scale, pitting, or surface defects; pickled and oiled.

C. Metallic-Coated Steel Sheet: ASTM A 653/A 653M, Commercial Steel (CS), Type B; with minimum G60 (Z180) or A60 (ZF180) metallic coating.

D. Frame Anchors: ASTM A 591/A 591M, Commercial Steel (CS), 40Z (12G) coating designation; mill phosphatized.
   1. For anchors built into exterior walls, steel sheet complying with ASTM A 1008/A 1008M or ASTM A 1011/A 1011M, hot-dip galvanized according to ASTM A 153/A 153M, Class B.

E. Inserts, Bolts, and Fasteners: Hot-dip galvanized according to ASTM A 153/A 153M.

F. Powder-Actuated Fasteners in Concrete: Fastener system of type suitable for application indicated, fabricated from corrosion-resistant materials, with clips or other accessory devices for attaching hollow metal frames of type indicated.

G. Grout: ASTM C 476, except with a maximum slump of 4 inches (102 mm), as measured according to ASTM C 143/C 143M.

H. Mineral-Fiber Insulation: ASTM C 665, Type I (blankets without membrane facing); consisting of fibers manufactured from slag or rock wool with 6- to 12-lb/cu. ft. (96- to 192-kg/cu. m) density; with maximum flame-spread and smoke-

development indexes of 25 and 50, respectively; passing ASTM E 136 for combustion characteristics.

I. Glazing: Comply with requirements in Division 8 Section "Glazing."

J. Bituminous Coating: Cold-applied asphalt mastic, SSPC-Paint 12, compounded for 15-mil (0.4-mm) dry film thickness per coat. Provide inert-type noncorrosive compound free of asbestos fibers, sulfur components, and other deleterious impurities.

2.3 STANDARD HOLLOW METAL DOORS

A. General: Provide doors of design indicated, not less than thickness indicated; fabricated with smooth surfaces, without visible joints or seams on exposed faces unless otherwise indicated. Comply with ANSI/SDI A250.8.
   1. Design: Flush panel.
   2. Core Construction: Manufacturer's standard kraft-paper honeycomb, polystyrene, polyurethane, polyisocyanurate, mineral-board, or vertical steel-stiffener core.
      a. Fire Door Core: As required to provide fire-protection and temperature-rise ratings indicated.
      b. Thermal-Rated (Insulated) Doors: Where indicated, provide doors fabricated with thermal-resistance value (R-value) of not less than 12.3 deg F x h x sq. ft./Btu (2.166 K x sq. m/W) when tested according to ASTM C 1363.
         1) Locations: Exterior doors
   3. Vertical Edges for Single-Acting Doors: Manufacturer's standard.
      a. Beveled Edge: 1/8 inch in 2 inches (3 mm in 50 mm).
   4. Vertical Edges for Double-Acting Doors: Round vertical edges with 2-1/8-inch (54-mm) radius.
   5. Top and Bottom Edges: Closed with flush or inverted 0.042-inch-(1.0-mm-) thick, end closures or channels of same material as face sheets.
   6. Tolerances: Comply with SDI 117, "Manufacturing Tolerances for Standard Steel Doors and Frames."

B. Interior Doors: Face sheets fabricated from cold-rolled steel sheet unless metallic-coated sheet is indicated]. Provide doors complying with requirements indicated below by referencing ANSI/SDI A250.8 for level and model and ANSI/SDI A250.4 for physical performance level:
   1. Level 2 and Physical Performance Level B (Heavy Duty) galvanized Model 1 (Full Flush)

C. Hardware Reinforcement: Fabricate according to ANSI/SDI A250.6 with reinforcing plates from same material as door face sheets.

D. Fabricate concealed stiffeners and hardware reinforcement from either cold- or hot-rolled steel sheet.

2.4 STANDARD HOLLOW METAL FRAMES

A. General: Comply with ANSI/SDI A250.8 and with details indicated for type and profile.

B. Interior Frames: Fabricated from cold-rolled steel sheet unless metallic-coated sheet is indicated.
   1. Fabricate frames with mitered or coped corners.
   2. Fabricate frames as full profile welded, galvanized.
   3. Frames for Level 2 Steel Doors: 0.053-inch- (1.3-mm-) thick steel sheet.
   4. Frames for Borrowed Lights: Same as adjacent door frame.

C. Hardware Reinforcement: Fabricate according to ANSI/SDI A250.6 with reinforcement plates from same material as frames.

2.5 FRAME ANCHORS

A. Jamb Anchors:
   1. Masonry Type: Adjustable strap-and-stirrup or T-shaped anchors to suit frame size, not less than 0.042 inch (1.0 mm) thick, with corrugated or perforated straps not less than 2 inches (50 mm) wide by 10 inches (250 mm) long; or wire anchors not less than 0.177 inch (4.5 mm) thick.
   2. Stud-Wall Type: Designed to engage stud, welded to back of frames; not less than 0.042 inch (1.0 mm) thick.
   3. Compression Type for Drywall Slip-on Frames: Adjustable compression anchors.
   4. Postinstalled Expansion Type for In-Place Concrete or Masonry: Minimum 3/8-inch- (9.5-mm-) diameter bolts with expansion shields or inserts. Provide pipe spacer from frame to wall, with throat reinforcement plate, welded to frame at each anchor location.

B. Floor Anchors: Formed from same material as frames, not less than 0.042 inch (1.0 mm) thick, and as follows:
   1. Monolithic Concrete Slabs: Clip-type anchors, with two holes to receive fasteners.
   2. Separate Topping Concrete Slabs: Adjustable-type anchors with extension clips, allowing not less than 2-inch (50-mm) height adjustment. Terminate bottom of frames at finish floor surface.

2.6 HOLLOW METAL PANELS

A. Provide hollow metal panels of same materials, construction, and finish as specified for adjoining hollow metal work.

2.7 STOPS AND MOLDINGS

A. Moldings for Glazed Lites in Doors: Minimum 0.032 inch (0.8 mm) thick, fabricated from same material as door face sheet in which they are installed.

B. Fixed Frame Moldings: Formed integral with hollow metal frames, a minimum of 5/8 inch (16 mm) high unless otherwise indicated.

C. Loose Stops for Glazed Lites in Frames: Minimum 0.032 inch (0.8 mm) thick, fabricated from same material as frames in which they are installed.

2.8 ACCESSORIES

A. Mullions and Transom Bars: Join to adjacent members by welding or rigid mechanical anchors.

B. Grout Guards: Formed from same material as frames, not less than 0.016 inch (0.4 mm) thick.

2.9 FABRICATION

A. Fabricate hollow metal work to be rigid and free of defects, warp, or buckle. Accurately form metal to required sizes and profiles, with minimum radius for thickness of metal. Where practical, fit and assemble units in manufacturer's plant. To ensure proper assembly at Project site, clearly identify work that cannot be permanently factory assembled before shipment.

B. Tolerances: Fabricate hollow metal work to tolerances indicated in ANSI/NAAMM-HMMA 861.

C. Hollow Metal Doors:
   1. Exterior Doors: Provide weep-hole openings in bottom of exterior doors to permit moisture to escape. Seal joints in top edges of doors against water penetration.
   2. Glazed Lites: Factory cut openings in doors.
   3. Astragals: Provide overlapping astragal on one leaf of pairs of doors where required by NFPA 80 for fire-performance rating or where indicated. Extend minimum 3/4 inch (19 mm) beyond edge of door on which astragal is mounted.

D. Hollow Metal Frames: Where frames are fabricated in sections due to shipping or handling limitations, provide alignment plates or angles at each joint, fabricated of same thickness metal as frames.
   1. Welded Frames: Weld flush face joints continuously; grind, fill, dress, and make smooth, flush, and invisible.

2. Sidelight and Transom Bar Frames: Provide closed tubular members with no visible face seams or joints, fabricated from same material as door frame. Fasten members at crossings and to jambs by butt welding.
3. Provide countersunk, flat- or oval-head exposed screws and bolts for exposed fasteners unless otherwise indicated.
4. Grout Guards: Weld guards to frame at back of hardware mortises in frames to be grouted.
5. Floor Anchors: Weld anchors to bottom of jambs and mullions with at least four spot welds per anchor.
6. Jamb Anchors: Provide number and spacing of anchors as follows:
    a. Masonry Type: Locate anchors not more than 18 inches (457 mm) from top and bottom of frame. Space anchors not more than 32 inches (813 mm) o.c. and as follows:
        1) Two anchors per jamb up to 60 inches (1524 mm) high.
        2) Three anchors per jamb from 60 to 90 inches (1524 to 2286 mm) high.
        3) Four anchors per jamb from 90 to 120 inches (2286 to 3048 mm) high.
        4) Four anchors per jamb plus 1 additional anchor per jamb for each 24 inches (610 mm) or fraction thereof above 120 inches (3048 mm) high.
    b. Compression Type: Not less than two anchors in each jamb.
    c. Postinstalled Expansion Type: Locate anchors not more than 6 inches (152 mm) from top and bottom of frame. Space anchors not more than 26 inches (660 mm) o.c.
7. Door Silencers: Except on weather-stripped doors, drill stops to receive door silencers as follows. Keep holes clear during construction.
    a. Single-Door Frames: Drill stop in strike jamb to receive three door silencers.
    b. Double-Door Frames: Drill stop in head jamb to receive two door silencers.

E. Fabricate concealed stiffeners, edge channels, and hardware reinforcement from either cold- or hot-rolled steel sheet.

F. Hardware Preparation: Factory prepare hollow metal work to receive templated mortised hardware; include cutouts, reinforcement, mortising, drilling, and tapping according to the Door Hardware Schedule and templates furnished as specified in Division 8 Section 08 71 00, Door Hardware.
1. Locate hardware as indicated, or if not indicated, according to ANSI/NAAMM-HMMA 861.
2. Reinforce doors and frames to receive nontemplated, mortised and surface-mounted door hardware.
3. Comply with applicable requirements in ANSI/SDI A250.6 and ANSI/DHI A115 Series specifications for preparation of hollow metal work for hardware.

4. Coordinate locations of conduit and wiring boxes for electrical connections with Division 16 Sections.

G. Stops and Moldings: Provide stops and moldings around glazed lites where indicated. Form corners of stops and moldings with butted or mitered hairline joints.
   1. Single Glazed Lites: Provide fixed stops and moldings welded on secure side of hollow metal work.
   2. Provide fixed frame moldings on outside of exterior and on secure side of interior doors and frames.
   3. Provide loose stops and moldings on inside of hollow metal work.
   4. Coordinate rabbet width between fixed and removable stops with type of glazing and type of installation indicated.

2.10 FINISHES

A. Prime Finish: Apply manufacturer's standard primer immediately after cleaning and pretreating.
   1. Shop Primer: Manufacturer's standard, fast-curing, lead- and chromate-free primer complying with ANSI/SDI A250.10 acceptance criteria; recommended by primer manufacturer for substrate; compatible with substrate and field-applied coatings despite prolonged exposure.

B. Factory-Applied Paint Finish: Manufacturer's standard, complying with ANSI/SDI A250.3 for performance and acceptance criteria.
   1. Color and Gloss: As selected by Architect from manufacturer's full range.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in for embedded and built-in anchors to verify actual locations before frame installation.

C. For the record, prepare written report, endorsed by Installer, listing conditions detrimental to performance of the Work.

D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Remove welded-in shipping spreaders installed at factory. Restore exposed finish by grinding, filling, and dressing, as required to make repaired area smooth, flush, and invisible on exposed faces.

B. Prior to installation, adjust and securely brace welded hollow metal frames for squareness, alignment, twist, and plumbness to the following tolerances:
   1. Squareness: Plus or minus 1/16 inch (1.6 mm), measured at door rabbet on a line 90 degrees from jamb perpendicular to frame head.
   2. Alignment: Plus or minus 1/16 inch (1.6 mm), measured at jambs on a horizontal line parallel to plane of wall.
   3. Twist: Plus or minus 1/16 inch (1.6 mm), measured at opposite face corners of jambs on parallel lines, and perpendicular to plane of wall.
   4. Plumbness: Plus or minus 1/16 inch (1.6 mm), measured at jambs on a perpendicular line from head to floor.

C. Drill and tap doors and frames to receive nontemplated, mortised, and surface-mounted door hardware.

3.3 INSTALLATION

A. General: Install hollow metal work plumb, rigid, properly aligned, and securely fastened in place; comply with Drawings and manufacturer's written instructions.

B. Hollow Metal Frames: Install hollow metal frames of size and profile indicated. Comply with ANSI/SDI A250.11.
   1. Set frames accurately in position, plumbed, aligned, and braced securely until permanent anchors are set. After wall construction is complete, remove temporary braces, leaving surfaces smooth and undamaged.
      a. At fire-protection-rated openings, install frames according to NFPA 80.
      b. Where frames are fabricated in sections because of shipping or handling limitations, field splice at approved locations by welding face joint continuously; grind, fill, dress, and make splice smooth, flush, and invisible on exposed faces.
      c. Install frames with removable glazing stops located on secure side of opening.
      d. Install door silencers in frames before grouting.
      e. Remove temporary braces necessary for installation only after frames have been properly set and secured.
      f. Check plumbness, squareness, and twist of frames as walls are constructed. Shim as necessary to comply with installation tolerances.
      g. Field apply bituminous coating to backs of frames that are filled with grout containing antifreezing agents.

2. Floor Anchors: Provide floor anchors for each jamb and mullion that extends to floor, and secure with postinstalled expansion anchors.
   a. Floor anchors may be set with powder-actuated fasteners instead of postinstalled expansion anchors if so indicated and approved on Shop Drawings.
3. Masonry Walls: Coordinate installation of frames to allow for solidly filling space between frames and masonry with grout.
4. Concrete Walls: Solidly fill space between frames and concrete with grout. Take precautions, including bracing frames, to ensure that frames are not deformed or damaged by grout forces.
5. In-Place Concrete or Masonry Construction: Secure frames in place with postinstalled expansion anchors. Countersink anchors, and fill and make smooth, flush, and invisible on exposed faces.
6. Installation Tolerances: Adjust hollow metal door frames for squareness, alignment, twist, and plumb to the following tolerances:
   a. Squareness: Plus or minus 1/16 inch (1.6 mm), measured at door rabbet on a line 90 degrees from jamb perpendicular to frame head.
   b. Alignment: Plus or minus 1/16 inch (1.6 mm), measured at jambs on a horizontal line parallel to plane of wall.
   c. Twist: Plus or minus 1/16 inch (1.6 mm), measured at opposite face corners of jambs on parallel lines, and perpendicular to plane of wall.
   d. Plumbness: Plus or minus 1/16 inch (1.6 mm), measured at jambs at floor.

C. Hollow Metal Doors: Fit hollow metal doors accurately in frames, within clearances specified below. Shim as necessary.
   1. Non-Fire-Rated Standard Steel Doors:
      a. Jambs and Head: 1/8 inch (3 mm) plus or minus 1/16 inch (1.6 mm).
      b. Between Edges of Pairs of Doors: 1/8 inch (3 mm) plus or minus 1/16 inch (1.6 mm).
      c. Between Bottom of Door and Top of Threshold: Maximum 3/8 inch (9.5 mm).
      d. Between Bottom of Door and Top of Finish Floor (No Threshold): Maximum 3/4 inch (19 mm).
   2. Fire-Rated Doors: Install doors with clearances according to NFPA 80.

D. Glazing: Comply with installation requirements in Division 8 and with hollow metal manufacturer's written instructions.
   1. Secure stops with countersunk flat- or oval-head machine screws spaced uniformly not more than 9 inches (230 mm) o.c. and not more than 2 inches (50 mm) o.c. from each corner.

3.4 ADJUSTING AND CLEANING

A. Final Adjustments: Check and readjust operating hardware items immediately before final inspection. Leave work in complete and proper operating condition.

Remove and replace defective work, including hollow metal work that is warped, bowed, or otherwise unacceptable.

B. Remove grout and other bonding material from hollow metal work immediately after installation.

C. Prime-Coat Touchup: Immediately after erection, sand smooth rusted or damaged areas of prime coat and apply touchup of compatible air-drying, rust-inhibitive primer.

D. Metallic-Coated Surfaces: Clean abraded areas and repair with galvanizing repair paint according to manufacturer's written instructions.

+ + END OF SECTION + +

SECTION 08 62 00

UNIT SKYLIGHTS

PART 1 - GENERAL

1.1 DESCRIPTION

A. Scope:
   1. CONTRACTOR shall provide all labor, materials, equipment, and incidentals as shown, specified, and required to furnish and install all unit skylight Work.
   2. Extent of unit skylight Work is shown.

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

C. Related Sections:
   1. Section 07 92 00, Joint Sealants.
   2. Section 09 91 00, Painting.

1.2 REFERENCES

A. Standards referenced in this Section are:
   1. Architectural Aluminum Manufacturers Association, (AAMA), AAMA 1603.1, Voluntary Standard Test Method for Thermal Transmittance of Skylights.
   2. ASTM A167, Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet and Strip.
   3. ASTM B209, Specification for Aluminum and Aluminum-Alloy Sheet and Plate.
   4. ASTM C920, Specification for Elastomeric Joint Sealants.
   5. ASTM D1003, Test Method for Haze and Luminous Transmittance of Transparent Plastics.
   6. ASTM D1044, Test Methods for Resistance of Transparent Plastics to Surface Abrasion.
   7. ASTM D2822, Specification for Asphalt Roof Cement.
   8. AWPB LP2, Pressure Treated with Water-borne Preservatives, Above Ground Use.
   9. FS TT-C-494, Coating Compound, Bituminous, Solvent Type, Acid Resistant.
   10. SSPC Paint 12, Cold Applied Asphalt Mastic (Extra Thick Film).
   11. UL 790, Standard Test Methods for Fire Tests of Roof Coverings.

1.3 QUALITY ASSURANCE

A. Qualifications:
   1. Manufacturer:
      a. Shall have a minimum of five years experience producing substantially similar products to those specified and shall be able to document of at least five installations in satisfactory operation for at least five years.
      b. Engage one manufacturer, with undivided responsibility for furnishing products and services for unit skylight Work.
   2. Installer:
      a. Engage installer regularly engaged in unit skylight installation and with five years experience in installing types of materials required; and who employs only tradesmen with specific skill and experience in this type of Work. Submit name and qualifications of installer.
      b. Engage one installer for all unit skylight Work with undivided responsibility for performance and other requirements.

B. Component Supply and Compatibility:
   1. Obtain all products included in this Section regardless of component manufacturer from a single unit skylight manufacturer.
   2. Skylight manufacturer shall review and approve or to prepare all Shop Drawings and other submittals for components provided under this Section.
   3. Components shall be specifically constructed for specified service conditions and be integrated into overall assembly by unit skylight manufacturer.

C. Regulatory Requirements:
   1. Building code specified in Section 01 42 00, References.

1.4 SUBMITTALS

A. Action Submittals: Provide the following:
   1. Shop Drawings:
      a. Assembly of entire unit skylight system, showing all dimensions, gages, finishes, location of joints, wood blocking, connections, fasteners, and locations and types of glazing gaskets, and other related items, as required. Provide detail sections of curb and skylight units.
   2. Product Data:
      a. Manufacturer's product literature and specifications.

B. Informational Submittals: Provide the following:
   1. Supplier's installation instructions:
      a. CONTRACTOR'S procedures for protecting unit skylights following installation and prior to final inspection.
   2. Qualifications Statements:
      a. Manufacturer.
      b. Installer.

1.5 DELIVERY, STORAGE AND HANDLING

A. Packing, Shipping, Handling, and Unloading:
   1. Deliver products to Site to ensure uninterrupted progress of the Work. Deliver anchorage products to be embedded in concrete in ample time to prevent delaying the Work.
   2. Inspect all boxes, crates, and packages upon delivery to Site and notify ENGINEER in writing of loss or damage to products. Promptly remedy loss and damage to new condition per manufacturer's instructions.
   3. Conform to Section 01 65 00, Product Delivery Requirements.

B. Storage and Protection:
   1. Keep all products off ground using pallets, platforms, or other supports. Protect steel and packaged materials from corrosion and deterioration.
   2. Conform to Section 01 66 00, Product Storage and Handling Requirements.

PART 2 - PRODUCTS

2.1 SYSTEM PERFORMANCE

A. System Description:
   1. Provide manufacturer's standard units modified as necessary to comply with the Contract Documents. Shop-fabricate each unit to greatest extent possible.

B. Design Criteria:
   1. Standards: Comply with the following applicable standards, except when more stringent requirements are specified in the Contract Documents.
      a. AAMA 1603.1.
      b. Glazing shall pass Class "B" burning brand test for flame spread and smoke contribution as specified in UL 790.
   2. Thermal Efficiency: Total thermal loss of entire unit skylight due to conductivity and air infiltration shall not exceed 5.1 BTU per hour per degree F.
   3. Air infiltration shall be less than 0.1 cfm per foot at 7.5 mph wind velocity.

2.2 MANUFACTURERS

A. Manufacturers: Provide products of one of the following:
   1. Wasco Products, Inc.
   2. Or equal.

2.3 MATERIALS

A. Stainless Steel: AISI Type 302/304, ASTM A167, 2D annealed finish, except as otherwise indicated, temper as required for forming and performance.

B. Aluminum Sheet: ASTM B209, Alloy 3003, temper as required for forming and performance; AA-C22-A42 dark bronze anodized finish, except mill finish prepared for painting where indicated.

C. Extruded Aluminum: Manufacturer's standard extrusions of sizes and general profiles shown, Alloy 6063-T52; 0.078-inch minimum thicknesses for primary framing and curb member legs, 0.062-inch for secondary legs; AA-C22-A42 dark bronze anodized finish on exposed members, except as otherwise indicated.

D. Insulation: Manufacturer's standard rigid or semi-rigid board of glass fiber of thicknesses indicated.

E. Wood Blocking and Nailers: Softwood lumber, pressure treated with water-borne preservatives for above-ground use, complying with AWPB LP2, not less than two inches thick.

F. Fasteners: Same material as metals being fastened, or non-magnetic stainless steel or other non-corrosive metal as recommended by manufacturer. Match finish of exposed fasteners with finish of material being fastened.

G. Gaskets: Tubular or fingered design of neoprene or polyvinyl chloride, or block design of sponge neoprene.

H. Bituminous Coating: FS TT-C-494 or SSPC Paint 12, solvent type bituminous mastic, nominally free of sulfur, compounded for 15-mil dry film thickness per coat.

I. Elastomeric Sealant: Generic type recommended by skylight manufacturer, compatible with joint surfaces. Comply with ASTM C920.

J. Roofing Cement: Comply with ASTM D2822, asphaltic.

2.4 FABRICATION

A. Plastic Unit skylights:
   1. Sheet Thicknesses: Provide minimum thickness of 1/4-inch, except where additional thickness is required for light transmittances. Provide glazing plastic sheet thickness required for 40 pounds per square foot external loading and 35 pounds per square foot internal loading pressures; comply with thickness recommendations of AAMA 1603.1. Plastic shall conform to ASTM D1044.
   2. Profile: Pyramidal double-sheet insulating units with average one-inch minimum air space between sheets, manufacturer's standard hermetic edge seal.
   3. Color, Exterior Sheet: Bronze tinted sheet, 25 to 30 percent light transmittance conforming to ASTM D1003.
   4. Color, Interior Sheet: Colorless transparent sheet.

5. Glazing Frame, Dome Retainer, Trim: Extruded aluminum.
6. Curb Frame: Provide nine-inch high prefabricated curbs consisting of inner and outer aluminum skins thermally separated by a vinyl curb at the top, one-inch unfaced fiberglass insulation in body and vinyl extrusion at bottom. Provide fused corners, condensation gutter, and four-inch wide continuous aluminum nailing mounting flange at base integral with outer aluminum skin.
7. Glazing System: Neoprene, closed-cell sponge neoprene, or PVC gasketing, or of partially vulcanized butyl tape or liquid-applied elastomeric sealant. Provide bronze tinted outer dome with clear inner dome.
8. Condensation Control: Fabricate units with integral internal gutters and non-clogging weeps for permanent control of condensation on inside of domes.

PART 3 - EXECUTION

3.1 INSPECTION

A. Examine conditions under which unit skylights are to be installed and notify ENGINEER in writing of conditions detrimental to proper and timely completion of the Work. Do not proceed with the Work until unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Installation Requirements:
   1. Install unit skylights and related components in accordance with manufacturer's written instructions, approved submittals, and the Contract Documents.
   2. Anchor enclosures permanently to substrate by methods in accordance with approved Shop Drawings. Anchorages shall be adequate for sizes and locations of units and adequate to withstand lateral and thermal stresses and inward and outward loading pressures.
   3. Protection of Aluminum from Dissimilar Materials: Coat all aluminum surfaces in contact with dissimilar materials, such as concrete, masonry, steel and other metals, as specified in Section 09 91 00, Painting.
   4. Seal all joints to provide a permanently watertight closure in accordance with Section 07 92 00, Joint Sealants.
   5. Clean exposed metal and plastic surfaces of unit skylight in accordance with manufacturer's instructions as required for preventing deterioration and uneven weathering.
   6. Advise ENGINEER in writing of protection and surveillance requirements that CONTRACTOR shall provide, at no additional cost to OWNER, to ensure that unit skylights will be without deterioration or damage at the time of final inspection.
   7. Clean and polish inside and outside of plastic unit skylight within five days prior to date of Substantial Completion.

3.3 FIELD QUALITY CONTROL

A. Field Testing:
   1. After nominal cure of exterior joint sealants exposed to weather, test all exposed unit skylight joints for water leakage.
   2. Flood exposed joint with water from garden hose without nozzle held perpendicular to wall face, 2.0 feet from joint. Hose shall discharge water at 30 pounds per square inch minimum pressure. Move stream of water along joint at approximate rate of 20 feet per minute.
   3. Conduct test in presence of ENGINEER.
   4. Criteria for Acceptance: No evidence of leakage is allowed.
   5. Repair joints that fail test and re-test until satisfactory results are achieved.

+ + END OF SECTION + +

SECTION 08 71 00

DOOR HARDWARE

PART 1 – GENERAL

1.1 SUMMARY

A. Scope
   1. CONTRACTOR shall provide all labor, materials, tools, equipment and incidentals as shown, specified and required to furnish and install door hardware. Furnish door hardware for all doors in compliance with these Specifications herein.
   2. Extent of door hardware is specified. Door hardware is defined to include all items known commercially as door hardware, except special types of unique and non matching hardware specified in the same Section as the door and door frame.

B. Coordination:
   1. Review installation procedures under other Sections and coordinate the installation of items that must be installed with, or before, the door hardware.
   2. Notify other contractors in advance of the installation of the door hardware to provide them with sufficient time for the installation of items included in their contracts that must be installed with, or before, the door hardware.
   3. Coordinate the Work of other Sections to provide clearances and accurate positioning of recessed or cast-in-place items.

C. Related Sections:
   1. Section 08 11 13, Hollow Metal Doors and Frames.

1.2 REFERENCES

A. Standards referenced in this Section are listed below:
   1. American National Standards Institute, (ANSI).
      a. ANSI A117.1, Accessible and Usable Buildings and Facilities.
   2. American National Standards Institute, (ANSI), in association with Builders Hardware Manufacturers' Association, (ANSI/BHMA).
      a. ANSI/BHMA A156.1, Butts and Hinges.
      b. ANSI/BHMA A156.3, Exit Devices.
      c. ANSI/BHMA A156.4, Door Controls - Closers.
      d. ANSI/BHMA A156.6, Architectural Door Trim.
      e. ANSI/BHMA A156.7, Template Hinge Dimensions.
      f. ANSI/BHMA A156.8, Door Controls - Overhead Stops and Holders.
      g. ANSI/BHMA A156.13, Mortise Locks and Latches, Series 1000.

h. ANSI/BHMA A156.16, American National Standard for Auxiliary Hard-ware.
i. ANSI/BHMA A156.18, Hardware - Materials and Finishes.
j. ANSI/BHMA A156.21, Thresholds.
k. ANSI/BHMA A156.22, Door Gasketing and Edge Seal Systems.

3. ANSI, in association with Door and Hardware Institute, (ANSI/DHI).
   a. ANSI/DHI A115.1, Preparation of Mortise Locks in 1-3/8-inch and 1-3/4-inch Standard Steel Doors and Frames.
4. ANSI, in association with National Fire Protection Association, (ANSI/NFPA).
   a. ANSI/NFPA 252, Standard Methods of Fire Tests of Door Assemblies.
5. ANSI, in association with Underwriters' Laboratories, Inc., (UL).
   a. UL 10B, Fire Tests of Door Assemblies.
6. The Americans with Disabilities Act of 1990 (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).
7. Door and Hardware Institute, (DHI).
   a. DHI, Recommended Locations for Architectural Hardware for Standard Steel Doors and Frames.
   b. DHI, Recommended Locations for Builders' Hardware for Custom Steel Doors and Frames.
   c. DHI, Sequencing and Format for the Hardware Schedule.
8. Hollow Metal Manufacturers Association, Division of National Association of Architectural Metal Manufacturers, (HMMA).
   a. HMMA 830, Hardware Preparation and Locations for Hollow Metal Doors and Frames.
9. National Fire Protection Association, (NFPA).
   a. NFPA 80, Fire Doors and Fire Windows.
10. Steel Door Institute, (SDI).
    a. SDI 109, Hardware for Standard Steel Doors and Frames.
    b. SDI 118, Basic Fire Door Requirements.
11. Underwriters' Laboratories, Inc., (UL).
    a. UL 305, Panic Hardware.
    b. UL, Building Materials Directory.

1.3 SUBMITTALS

A. Schedules:
   1. The finish hardware supplier shall, upon award of the contract, furnish six (6) copies of a completely detailed schedule of finish hardware in "Vertical Format" in the Door and Hardware Institute's Sequence and Format for approval within 30 days. Hardware schedule to be complete with Title page, Door Index/Keying Schedule and Manufactures legend. After "Approval" provide six (6) copies, unless otherwise requested, of the corrected, revised and approved schedule for field use, distribution and files.

Provide one (1) copy complete with Catalog Cuts, marked "Installers Copy" and deliver it to the job site. Horizontal format schedules will be rejected.

B. Product Data:
   1. Provide a catalog cut, clearly marked and identified, illustrating and describing each product included in the hardware schedule. Formulate these catalog cuts into sets and include a set with each copy of the hardware schedule submitted.

C. Samples:
   1. If so requested by the Architect, provide a sample of any product or item requested, properly marked and tagged, for the opening for which it is intended. After examination and approval by the Architect, the sample shall be turned over to the General Contractor, for incorporation into the project.

D. Templates:
   1. Upon "Approved" copies of the hardware schedule, provide a complete "Template List". Further and upon request, provide copies to manufacturers or trades, whose work includes preparation of their products, to receive hardware. Provide copies of all such transmittals to the contractor, for their files. If physical samples are required, the manufacturer may request it from the general contractor and assume all responsibility of shipping it complete to the project.

E. Keying:
   1. The hardware supplier shall meet with owner and/or architect to establish keying requirements. Provide a keying schedule, listing the levels of keying, (GMKD, MKD, Keyed alike, etc.) as well as an explanation of the key's function, the symbols used and the numbers of the doors controlled. This shall be provided in reference to the Door and Hardware Institute's manual "Keying Systems and Nomenclature". Also in conjunction the Door Index/Keying Schedule (which lists the door number, schedule heading, lock type and individual key symbol and remarks or special instructions) mentioned in paragraph "B", Schedules.

F. Wiring Diagrams:
   1. Unless otherwise specifically stated, for any electrified hardware furnished on this project, provide complete point to point wiring diagrams along with riser drawings and elevations, showing locations where such material is to be installed. Also check with the system installer as to the scope of their work.

G. Operations and Maintenance Data:
   1. At the completion of the project, provide an Owner's Operation and Maintenance Manual. The manual shall consist of a hard three ring binder. Include a copy of the latest revised and updated schedule of finish hardware, complete with catalog cuts and keying schedule. In addition, furnish one

copy of maintenance and parts manual, for those items, for which they are readily available and normally provided.

1.4 QUALITY ASSURANCE

A. Substitutions:
   1. The manufacturers and catalog numbers listed are intended to establish a standard of quality. Items specified as "owner's standard" shall be provided as listed they have been requested by the Owner/Architect to match existing for continuity and/or future performance, maintenance standards or there is no equal product. Certain products have been selected for their unique characteristics and particular project suitability. Requests for substitutions will require architects approval and must be made in accordance with Division 01. Provide sample if requested. Substitution item will be reviewed and if approved it will be listed in an addendum prior to bid date.

B. Supplier Qualification:
   1. The hardware supplier must be engaged currently in the furnishing, delivery and servicing of contract builders hardware. The firm shall have been furnishing hardware on similar projects in the vicinity for not less than five (5) years. The supplier must employ a certified Architectural Hardware Consultant (AHC) qualification and be available at reasonable times during the course of this project for consultation with the owner, architect and general contractor.

C. Single source responsibility: Obtain each type of hardware (latches and locks, hinges, exit devices, door closers, etc) from a single manufacturer.

D. Fire-Rated Openings:
   1. Provide door hardware for fire-rated openings that complies with NFPA and requirements of authorities having jurisdiction. Provide only items of door hardware that are listed and are identical to products tested by Underwriters Laboratories, Warnock Hersey, Factory Mutual, or other testing and inspecting organization for given type/size and degree of label. Provide proper latching hardware, door closers, approved bearing hinges and seals whether listed in the hardware schedule or not. All hardware shall comply with standards UBC702 (1997) and UL10C. These must be acceptable to the authorities having jurisdiction for use on types and sizes of doors indicated in compliance with requirements of fire-rated door and frame labels.
      a. Where emergency exit devices are required on fire rated doors, (with supplementary marking on door' UL labels indicating "Fire Doors to be equipped with Fire Exit Hardware") provide UL label on exit devices indicating, "Fire Exit Hardware".

E. Electronic Security Hardware:
   1. When electrified hardware is included in the hardware specification, the hardware supplier must employ an individual knowledgeable in electrified

components and systems, who is capable of producing wiring diagrams and consulting as needed. Coordinate installation and technical data of the electronic security hardware with Architect, electrical engineers and other related contractors. Upon completion of the electronic security hardware installation, verify that components are working properly, and state in the required guarantee that this inspection has been performed. Provide electrical door hardware from the same source manufacturer as the mechanical door hardware.

1.5 DELIVERY, STORAGE AND HANDLING

A. Marking and packaging:
   1. All items of hardware shall be delivered to the job site, in the manufacturer's original packages, they shall be marked to correspond with approved hardware schedule, item number, heading number, door number and key sets symbols. Include installation instructions with each piece of hardware.

B. Delivery:
   1. The hardware supplier shall coordinate delivery with general contractor, in order to compile a mutually beneficial delivery schedule, which imposes no hardship on either party. Some items of the hardware may be delivered to fabricators for factory installation in such case, the general contractor shall be advised of such shipments, along with copies of shipping tickets and any other documentation, thus transferring responsibility to the manufacturer or fabricator, for care of said hardware. Any delivery fees will be in the quoted price of the material.

C. Storage:
   1. Hardware is to be delivered to the job site and stored in a clean dry, secure area, with adequate strong shelving. If requested by the contractor, the hardware supplier shall send a representative to the job site to "assist" the check in and laying-out of the hardware on the shelves. A representative of the contractor MUST be present. At this time any installation tips or special instructions will be reviewed.

D. No direct shipments will be allowed unless prior approval by the contractor.

1.6 WARRANTY

A. Starting date for all warranty periods will be from the date of substantial completion.

B. All material must carry a limited warranty against defects in workmanship and materials from the date of acceptance of the project as follows.
   1. Door Closers: at least ten (10) year warranty, except electronic closers, two (2) years

2. Exit Devices: at least three (3) year warranty, except electrified devices, one (1) year.
3. Locksets: at least seven (7) year warranty, except electrified devices, one (1) year.
4. Hinges: life of the building.
5. Balance of the hardware: one (1) year.

C. Products judged to be defective during the warranty period will be replaced or repaired in accordance with the manufacturer's warranty at no additional cost to the owner. However, NO warranty against defects due to improper installation or failure to exercise normal maintenance.

1.7 MAINTENANCE

A. Maintenance service:
1. If there are any products listed hereinafter that normally require a maintenance or service contract, provide the owner with details and costs of said contract.

B. Maintenance Tools and Instructions:
1. Furnish a complete set of specialized tools and maintenance instructions as needed for the owners continued adjustment, maintenance, and removal and the replacement of door hardware.

PART 2 – PRODUCTS

2.1 MANUFACTURERS:

A. The following manufacturers listed in 2.2 Materials have been selected for this project, whose products numbers have been used in the preparation for this specification.

B. Note that even though an acceptable substitute manufacturer may be listed, the product must provide all the functions and features of the specified product or it will not be approved.

C. Hand of Door: Drawings show direction of slide, swing, or hand of each door leaf. Furnish each item of hardware for proper installation and operation of door movement as shown.

D. Where the exact types of hardware specified are not adaptable to the finished shape or size of the members requiring hardware, furnish suitable types having as nearly as possible the same operation and quality as the type specified, subject to Architect's approval.

2.2 MATERIALS

A. Screws and Fasteners:
   1. Provide all screws and fasteners of the proper size and type to properly anchor or attach the item of hardware they are intended for. Provide all fasteners with Phillips head, do not use through-bolts for installation where bolt head or nut on opposite face is exposed in other work unless their use is the only means of reinforcing the work adequately to fasten the hardware securely.

B. Hinges:
   1. The following is a guide for hinge type required for this specification:
      a. 1-3/4" thick doors up to and including 3'0" wide:
         1) Exterior: standard (.134) or heavy weight (.180) ball bearing, bronze/stainless steel 4-1/2" high.
         2) Interior: standard (.134) or heavy weight (.180) plain or ball bearing, steel 4-1/2" high.
      b. 1-3/4" doors over 3'0" wide:
         1) Exterior: standard (.134) or heavy weight (.180) ball bearing, bronze/stainless steel 5" high.
         2) Interior: standard (.134) or heavy weight (.180) plain or ball bearing, steel 5" high.
      c. Furnish one pair of hinges for all doors up to 60" high. Furnish one additional hinge for every additional 30" or fraction thereof. The width of hinges shall be sufficient to clear all trim.
      d. Hinges specified Ives (IVE), approved acceptable substitute Hager, Stanley, McKinney

C. Continuous Hinges:
   1. Hinges shall be manufactured of three interlocking components and two hinge leafs. The door leaf and jamb leaf shall be pinned together for the entire length of the hinge. The assembly of three interlocking shall be applied to the full height of the door and frame without mortising.
      a. Continuous Hinges specified Ives (IVE), approved acceptable substitute Hager Roton, McKinney, Select

D. Automatic and Manual Flush Bolts:
   1. Shall have forged bronze faceplate with extruded brass lever and with wrought brass guide and strike. Flush bolts for hollow metal doors shall be extension rod type door up to 7'6" in height shall have 12" steel or brass rods, manual flush bolts for doors over 7'6" in height shall be increased by 6" for each additional 6" of door height. Wood doors shall have corner-wrap type. Provide dust proof strikes for all bottom bolts.
      a. Flush Bolts specified Ives (IVE), approved acceptable substitute DCI, Rockwood

E. Coordinators:

1. Where pairs of doors are equipped with automatic flush bolts, provide bar type coordinating device, surface applied to the underside of the stop at the frame head. Provide a filler bar of the correct length to span the entire width of the opening, and any appropriate brackets for parallel arm door closers, surface vertical rod strikes, and or any other hardware. Finish of the coordinator, filler bar and mounting brackets to be US28 unless otherwise noted.
    a. Coordinators specified Ives (IVE), approved acceptable substitute DCI, Rockwood

F. Mortise Locks:
1. Locks shall be ANSI A156.13, Grade 1 Operational, and manufactured from heavy gauge steel, containing components of steel with a zinc dichromate plating for corrosion resistance. Lock case shall be multi-function and field reversible for handing without opening the case. Cylinders: Refer to 2.04 KEYING.
2. Locks to have a standard 2-3/4" backset with a full 3/4" throw stainless steel mechanical anti-friction latch bolt. Deadbolt shall be a full 1" throw, constructed of stainless steel.
3. Provide standard ASA strikes unless extended lip strikes are necessary to protect trim.
4. Provide electrical options as scheduled. Provide electrified locksets with micro switch (RX) option that monitors the retractor crank, and is actuated when rotation of the inside or outside lever rotates the retractor hub. Provide normally closed contacts or normally open contacts as required by security system. All electrification and or additional switches shall be added to the mortise lock by the manufacturer of the mortise lock. Electric and Non-Electric additions to the mortise lock by a second manufacturer that void the warranty of the mortise lock manufacturer will not be acceptable.
5. Lever trim shall be cast or forged in the design specified, with 2-1/8" diameter roses with wrought roses and external lever spring cages. Levers shall be thru-bolted to assure proper alignment, and shall have a 2-piece spindle. Levers to be thru-bolted to assure proper alignment. Trim shall be applied by threaded bushing "no exposed screws".
6. Lever trim on the secure side of doors serving rooms considered by the authority having jurisdiction to be hazardous shall have a tactile warning.
7. Locks meeting this specification: Schlage (SCH) L9000 x 17L approved acceptable substitute Sargent 8200 series , Stanley Best 45H series

G. Exit Devices:
1. Exit devices shall be touch pad type, fabricated of brass, bronze, stainless steel, or aluminum, plated to the standard architectural finishes to match the balance of the door hardware.
2. Exit devices shall be tested to ANSI/BHMA A156.3 test requirements by a BHMA certified laboratory. A written certification showing successful completion of a minimum 1,000,000 cycles must be provided.

3. All exit devices shall incorporate a fluid damper or other device, which eliminates noise associated with the standard operation.
4. Touch pad shall extend a minimum of one half of the door width. Maximum unlatching force shall not exceed 15 pounds. End-cap will have three-point attachment to the door. Touch pad shall match exit device finish, and shall be stainless steel for US26, US26D, US28, US32, and US32D finishes.
5. Only compression springs will be used in devices, latches, and outside trim and/or controls.
6. All lever design shall match mortise lock lever designs.
7. All devices to incorporate a security dead-latching feature.
8. Provide roller strikes for all rim and surface mounted vertical rod devices, ASA strikes for mortise devices, and manufacturer's standard strikes for concealed vertical rod devices.
9. Device mechanism case and bar shall sit flush on the face of all flush doors, or spacers shall be furnished to fill gaps behind devices. Where glass trim or the moulding projects off the face of the door, provide glass bead kits.
10. Exit devices shall be UL listed panic exit hardware. All exit devices for fire rated openings shall be UL labeled fire exit hardware.
11. Provide electrical options as scheduled.
12. Exit devices meeting this specification: Von Duprin (VON) 98 series approved acceptable substitute None Owners Standard

H. Door Closers:
1. All closers will utilize a stable fluid withstanding temperature range of 120 degrees f to –30 degrees f without seasonal adjustment of closer speed to properly close the door. Closers on fire rated doors will be provided with temperature stabilizing fluid that complies with standard UL 10C for "Positive Pressure Fire Tests of Door Assemblies" and UBC 7-2 (1997).
2. Door closers shall hydraulic, full rack and pinion action with a high strength cast iron cylinder. Cylinder body shall be 1 1/2" in diameter, and double heat-treated pinion shall be 11/16" in diameter. A written certificate showing successful completion of a minimum or 10,000,000 cycles for exterior door closers must be provided.
3. Spring power shall be continuously adjustable over the full range of closer sizes, and allow for reduced opening force for the physically handicapped. Hydraulic regulation shall be by tamper-proof, non-critical valves. Closers shall have separate adjustment for latch speed, general speed, and back check.
4. All closer shall have forged steel main arms and forged forearms for parallel arm closers.
5. Closer cylinders and arms (and metal covers when specified) shall have a powder coating finish which has been certified to exceed 100 hours of salt spray testing by ETL, an independent testing laboratory used by BHMA for ANSI certification. For metal components that can't be powder coated, a special rust inhibiting finish (SRI) must be used.

6. All closers will not be seen on the public side or hallway side of the door. The appropriate drop plate or mounting plates will be used as conditions dictate.
7. Door closers meeting this specification: LCN (LCN) 4011, 4111 approved acceptable substitute None Owners Standard

I. Door Stops and Holders:
   1. It shall be the responsibility or the hardware supplier to provide doorstops for all doors in accordance with following requirements:
      a. Wall stops may be used wherever possible.
      b. Where wall stops cannot be used, provide dome type floor stops of the proper height.
      c. At any opening where a wall or floor stop cannot be used, a heavy-duty overhead stop will be required.
      d. At no time will a hinge pin stop be acceptable.
      e. Stops specified Ives (IVE), approved acceptable substitute Hager, Rockwood

J. Overhead Stops/Holders:
   1. Overhead door stops and holders; surface or concealed at the top of the door shall have shock absorber in extruded stainless steel case. Hold open and shock absorber feature that automatically engages and releases the door. Sliding member in the channel shall have accessible adjustment screw to regulate hold open tension.
   2. Overhead stops/holders specified Glynn-Johnson (GLY), approved acceptable substitute Sargent, Rixson

K. Thresholds and Gasketing:
   1. Furnish as specified and per details. Match finish of other items as closely as possible. Provide only those units where resilient or flexible seal strip is easily replaceable and readily available. Threshold, sweep and weather-stripping will be supplied to weather proof the exterior doors. The thresholds will be supplied to fit the particular sill conditions and not conflict with the American Disabilities Act (ADA). Exterior pairs of doors will have split astragal to prevent air infiltration. Interior doors may require gasketing, thresholds and sweeps to act as a sound barrier per the owner's request.
      a. Thresholds specified National Guard Products (NGP), approved acceptable substitute Reese, Zero

L. Silencers:
   1. Furnish Ives SR64 for the "push in type: for metal frames, Ives SR65 for wood frames, or Ives SR66 adhesive type. Supply 3 each for single doors, 2 each for pair of doors. Omit silencers where gasketing is scheduled.
      a. Silencers specified Ives (IVE), approved acceptable substitute Hager, Rockwood

M. Miscellaneous Items:
   1. Transom Spring Bolts specified Richard Wilcox (RIC), approved acceptable substitute architect approved.

2.3 FINISHES

A. All hardware is to be furnished in one of the following finishes, depending upon the item and its base metal. All satin chrome or satin stainless steel or as noted.

Item	**BHMA #**	**US #**
Hinges exterior	630	(US32D)
Hinges interior	630	(US32D)
Continuous Hinges	630	(US32D)
Flush Bolts	630	(US32D)
Coordinators	628	(US28)
Mounting Brackets	689	(alum painted)
Locks	630	(US32D)
Exit Devices	630	(US32D)
Door Closers	689	(alum painted)
Door wall stops	630	(US32D)
Overhead Holders	630	(US32D)

Other items to be 630 if available. If not, 626 over brass or bronze.

2.4 KEYING

A. All locksets shall be furnished with two (2) cut keys and with key code number stamped on the bow of the key. All cylinders shall be factory masterkeyed and grand masterkeyed as required. Furnish three (3) grand masterkeys and six (6) masterkeys for each masterkeyed group. The grand masterkeys and masterkeys shall be sent direct to the owner's representative by registered mail, return receipt requested.

B. Consult with OWNER and secure written approval of the complete keying layout prior to placing lock order with factory.
   1. Cylinders and Keying specified Schlage (SCH), approved acceptable substitute Sargent, Stanley Best

PART 3 – EXECUTION

3.1 EXAMINATION

A. Prior to installation of hardware, examine condition of opening size, shall be verified as to door frames being plumb and of correct tolerance, walls or any

related items that would prevent proper installation of doors and hardware. Correct any and all defects prior to proceeding with installation.

3.2 INSTALLATION

A. Prior to hardware installation the general contractor will set up a preinstall job site meeting with the hardware supplier, hardware installer and any other trades people deemed necessary (i.e. electrical contractor, security contractor, etc.) for communication to assure trouble free installation. This meeting would be best coordinated with the delivery requirements detained in section 1.05.

B. Review with the architect the mounting locations of various items of hardware in accordance with the Door and Hardware Institute's (DHI), "Recommended Locations for Architectural Hardware" for standard and custom steel doors and frames, and DHI's WDHS-3 for flush wood doors. Special attention to be given to all special and unusual conditions. All hardware shall be installed by carpenter mechanics skilled in the application of said hardware.

C. Install each hardware item in compliance with the manufacturer's instructions and recommendations, using only the fasteners provided by the manufacturer.

D. Set thresholds for exterior doors in a full bed of butyl-rubber or polyisobutylene mastic sealant complying with requirements specified in Division 7 "Joint-Sealers".

3.3 FIELD QUALITY CONTROL

A. After all hardware has been installed, provide the services of a qualified hardware consultant to check for proper installation of hardware, according to the "Approved" hardware and keying schedule's. Also, check the operation and adjustment of all hardware items in accordance with the manufacturer's recommendations.

3.4 ADJUSTING AND CLEANING

A. At final completion, hardware shall be left clean and free from disfigurement. Make final adjustment to all door closers and other items of hardware. Where hardware is found defective, repair or replace or otherwise correct as directed. After building is occupied, arrange an appointment with owner's representative to instruct in the proper use, servicing, adjusting and maintenance of the hardware.

B. Hardware items specified to receive antimicrobial coating may be cleaned with a mild detergent, air-dry or dried with soft cloth.

C. Avoid harsh abrasive cleaners and abrasive cleaning pads.

3.5 PROTECTION

A. Provide protection for all items of hardware during construction, to prevent damage, field painting or marring. Damaged or disfigured hardware shall be replaced or corrected by the responsible party.

3.6 HARDWARE SCHEDULE

A. Provide hardware for each door to comply with requirements of this section "Finish Hardware" hardware set numbers indicated in the door schedule, and in the following schedule of hardware sets.

B. It is intended that the following schedule includes all items of the finish hardware necessary to complete the work. If a discrepancy is found in the schedule, such as a missing item, improper hardware for a frame, door or fire codes, it shall be the responsibly of the hardware supplier to supply the proper materials.

C. Hardware Sets:

1. Set 1: 301-1

Qty	Description
6	Hinges
1	Closer
1	Panic Hardware
6	Silencers
2	Stops
1	Coordinator
1	Astragal
1	Flush Bolt

2. Set 2: 301-2

Qty	Description
3	Hinges
1	Closer
1	Panic Hardware
3	Silencers
1	Stops

+ + END OF SECTION + +

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SECTION 09 66 00

TERRAZZO FLOORING

PART 1 - GENERAL

1.1 DESCRIPTION

A. Scope:
   1. CONTRACTOR shall provide all labor, materials, tools, equipment and incidentals as shown, specified and required to furnish and install all terrazzo flooring.
   2. Extent of terrazzo flooring Work is shown.

B. Coordination:
   1. Review installation procedures under this and other Sections and coordinate the installation of items that must be installed with, or before, the terrazzo flooring Work.
   2. Coordinate and schedule shot blasting, grinding and installation of cementitious underlayments, to provide substrates within tolerances and surface profile specified.
   3. Coordinate required thickness of cementitious underlayments with doors, thresholds and adjacent materials to provide smoothly aligned transitions in compliance with the requirements of governing authorities having jurisdiction at the Site.
   4. Remove all chemicals, compounds and other materials from substrates that could preclude bonding of terrazzo flooring, even if chemicals, compounds and other materials are specified as acceptable for use in the Work under other Sections.
   5. Do not use liquid curing compounds on cast-in-place concrete floors shown to receive terrazzo flooring.

1.2 REFERENCES

A. Standards referenced in this Section are listed below:
   1. American Concrete Institute, (ACI).
      a. ACI 302.1R, Guide for Concrete Floor and Slab Construction.
      b. ACI 403, Bulletin Title No. 59-43.
   2. American Society for Testing and Materials, (ASTM).
      a. ASTM C 33, Specification for Concrete Aggregates.
      b. ASTM C 150, Specification for Portland Cement.
      c. ASTM C 157/C 157M, Test Method for Length Change of Hardened Hydraulic-Cement Mortar and Concrete.
      d. ASTM C 170, Test Method for Compressive Strength of Natural Building Stone.

e. ASTM C 241, Test Method for Abrasion Resistance of Stone Subjected to Foot Traffic.
f. ASTM C 267, Test Methods for Chemical Resistance of Mortars, Grouts and Monolithic Surfacings and Polymer Concretes.
g. ASTM C 293, Test Method for Flexural Strength of Concrete (Using Simple Beam with Center-Point Loading).
h. ASTM C 348, Test Method for Flexural Strength of Hydraulic Cement Mortars.
i. ASTM C 579, Test Methods for Compressive Strength of Chemical-Resistant Mortars, Grouts Monolithic Surfacings and Polymer Concretes.
j. ASTM D 570, Test Method for Water Absorption of Plastics.
k. ASTM D 635, Test Method for Rate of Burning and/or Extent and Time of Burning of Plastics in a Horizontal Position.
l. ASTM D 695, Test Method for Compressive Properties of Rigid Plastics.
m. ASTM D 696, Test Method for Coefficient of Linear Thermal Expansion of Plastics Between -30 Degrees C and 30 Degrees C with a Vitreous Silica Dilatometer.
n. ASTM D 1308, Test Method for Effect of Household Chemicals on Clear and Pigmented Organic Finishes.
o. ASTM D 2240, Test Method for Rubber Property - Durometer Hardness.
p. ASTM G 23, Practice for Operating Light-Exposure Apparatus (Carbon-Arc Type) With and Without Water for Exposure of Nonmetallic Materials.

3. National Terrazzo and Mosaic Association, Incorporated (NTMA), Guide Specifications.

1.3 QUALITY ASSURANCE

A. Source Quality Control:
1. In addition to specified requirements, comply with resin manufacturer's approved instructions and recommendations, including storing, mixing and applying materials, finishing, and curing of terrazzo flooring Work.
2. Materials shall comply with NTMA requirements. Submit these requirements along with verification of compliance.

B. Installer's Qualifications:
1. Installer shall be a member of NTMA in good standing and be certified to perform all the Work in accordance with NTMA Standards.
2. Engage a single installer regularly engaged in performing terrazzo flooring Work and with successful experience in the installation of the types of materials required; and who agrees to employ only tradesmen with specific skill and successful experience in this type of Work.
3. Submit name and qualifications to ENGINEER along with the following information on a minimum of three successful projects of the same magnitude and complexity:
a. Names and telephone numbers of owners, architects or engineers responsible for projects.

b. Approximate contract cost of the terrazzo flooring.
c. Amount of area installed.

C. Pre-Installation Conference:
1. Prior to the installation of terrazzo flooring, CONTRACTOR shall schedule a Pre-Installation Conference at the Site.
2. Notify ENGINEER and others, as specified, and submit proposed meeting agenda at least five days before scheduled date of conference. The agenda shall include a review of foreseeable methods and procedures related to the terrazzo flooring Work including, but not necessarily limited to, the following:
a. Project requirements, including Contract Documents.
b. Underbed preparation and installation.
c. Method of sequence of terrazzo flooring installation.
d. Special terrazzo flooring designs and patterns.
e. Required submittals, both completed and yet to be completed.
f. Standard of workmanship.
g. Quality control requirements.
h. Work organization and availability of materials, tradesmen, equipment and facilities needed to make progress and avoid delays.
i. Terrazzo flooring control and expansion joint locations and materials.
j. Modular planning requirements and special installation considerations.
k. Procedures for coping with unfavorable conditions and dust control procedures.
l. Required inspection, testing and certifying procedures.
3. Attendance is mandatory for the following:
a. CONTRACTOR'S superintendent.
b. Terrazzo flooring subcontractor's foreman.
c. ENGINEER'S authorized representative.
4. Reconvene the Pre-Installation Conference at the earliest opportunity if additional information must be developed in order to conclude the subjects under consideration.
5. Record the discussions of the conference and the decisions and agreements (or disagreements) and furnish a copy of the record to each party attending.

1.4 SUBMITTALS

A. Action Submittals: Submit the following:
1. Shop Drawings: Submit the following:
a. Copies of manufacturer's technical information and installation instructions for all materials required. Include requirements for environmental conditions and other conditions required for an acceptable installation.
b. Complete and coordinated plans drawn at 1/4-inch scale showing locations of all divider, control and expansion joint strips. Base positions of strips on dimensions obtained from measurements taken at the Site of the Work. Indicate the location of each NTMA color plate number based on terrazzo flooring patterns shown. Include location of all penetrations

through terrazzo flooring and all equipment and other items that interrupt terrazzo flooring patterns.

c. Completely dimensioned details drawn at 1-1/2-inch scale showing all jointing and edge conditions at accessory strips, cove bases, stair nosings, abrasive strips, control and expansion joints, termination in the Work and similar details. Include details of anchorage and other special features required.

2. Samples: Submit the following:
   a. Each pattern and color of terrazzo flooring required with all types of divider and similar type strips included on a thin-set sample panel not less than 12-inches square. Provide original, full color print copies of all NTMA color plate numbers shown or specified, for acceptance by ENGINEER.
   b. Six-inch lengths of all accessories.
   c. Samples will be reviewed for color, pattern, texture and workmanship only. Compliance with all other requirements is the responsibility of CONTRACTOR.
   d. Installer's Qualifications: Submit qualifications in accordance with Article 1.3, above.

B. Informational Submittals: Submit the following:
   1. Certificates: Submit copies of manufacturer's written certification that terrazzo flooring materials meet or exceed specified NTMA properties requirements.

C. Closeout Submittals: Submit the following:
   1. Maintenance Instructions: Upon completion of the Work, submit five copies of NTMA written instructions for recommended periodic maintenance of terrazzo flooring Work.

1.5 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 ample time to prevent delay of that Work.
   2. Only materials approved at the time of Shop Drawing submission shall be delivered to the Site.
   3. Do not open containers or bags until all preparatory Work is complete and installation will start immediately.
   4. Handle materials to prevent the inclusion of foreign materials and contaminants.

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. Do not allow materials to become wet or covered with ice or snow.

C. Acceptance at Site:
   1. All boxes, crates and packages shall be inspected by CONTRACTOR upon delivery to the Site. CONTRACTOR shall notify ENGINEER, in writing, if any loss or damage exists to equipment or components. Replace loss and repair damage to new condition in accordance with manufacturer's instructions.

1.6 PROJECT CONDITIONS

A. Scheduling and Sequencing:
   1. Complete terrazzo flooring installation before the installation of other items, which might be damaged by the spillage of water, resin or other materials required by the Work.
   2. Sequence the Work so that other installers do not interfere with, or need to cross, the terrazzo flooring installation areas until such time as the terrazzo flooring Work can be adequately protected from potential damage that may be caused by the Work, or access requirements of, other installers.

B. Environmental Requirements:
   1. Supplemental Heat:
      a. Provide supplemental heat and protection as required to maintain terrazzo flooring at minimum of 50°F during and after installation.
      b. Supplemental heat and power sources, as may be required should ambient temperature fall below 50°F, are not available at the Site. The provision of all supplemental heat, including fuel, equipment, operating and maintenance personnel and power sources, is the responsibility of CONTRACTOR.
   2. Distribute heat uniformly and provide deflection or protective screens as required to prevent concentration of heat on terrazzo flooring Work near heat source.
   3. Warm Weather Requirements: Protect terrazzo flooring Work against uneven and excessive evaporation and from strong flows of dry air, both natural and artificial. Apply and cure terrazzo flooring as required by climatic and Site conditions to prevent dry-out during cure period. Provide suitable coverings, moist-curing, barriers to deflect sunlight and wind, or combinations of these, as required.
   4. Ventilation Requirements: Provide natural or mechanical means of ventilation to remove water in excess of that required for hydrating cement after application. Begin ventilation immediately after terrazzo flooring is applied and continue until it sets.
      a. If glass is not in place and areas to receive terrazzo flooring are subjected to hot dry winds or will be subjected to temperature differentials of 20°F or more, cover openings with polyethylene film arranged to allow proper ventilation without excessive, non-uniform curing or temperature variations.
      b. Avoid conditions that result in terrazzo flooring Work drying too rapidly. Provide moisture-cure and maintain relative humidity levels appropriate

for prevailing ambient temperatures that will produce normal curing conditions.

C. Site-Measurements:
   1. Verify actual dimensions in areas of installation by measurements taken at the Site before installation. Indicate dimensions on Shop Drawings.
   2. Where measurements cannot be made without delaying the Work, establish dimensions and proceed with Shop Drawing preparation without Site verified dimensions. Coordinate supports, adjacent construction, and equipment locations to ensure actual dimensions shown on Shop Drawings correspond to dimensions established for terrazzo flooring Work.

PART 2 - PRODUCTS

2.1 SYSTEM PERFORMANCE

A. Design Criteria:
   1. Terrazzo Flooring Selections:
      a. Match existing color, stone density, blend and size of existing aggregate. Provide same matrix color and material as existing, unless otherwise specified. Provide same strip width, material and divider strip pattern required to match, and be continuous with, existing patterns. Align face of new Work with existing.
   2. Thickness: Provide finished terrazzo flooring thickness of 3/8-inch.
   3. Minimum Allowance for Thickness of Terrazzo Flooring at Localized High Points in Substrate: 1/4-inch.

B. Performance Standards:
   1. Comply with applicable guide specifications and recommendations of NTMA.

C. Materials:
   1. Polyacrylate Modified Portland Cement Terrazzo Flooring: Provide the following physical properties in the finished terrazzo flooring system:
      a. Matrix Odor: Free from objectionable odors under ordinary service conditions.
      b. Bond Strength, ACI 403 Bulletin Title No. 59-43: 300 psi, minimum.
      c. Tensile Strength, ASTM C 170: 1,000 psi, minimum after aging 28 days. Tensile strength shall not change more than 20 percent between -10 and +180°F.
      d. Flexural Strength, ASTM C 348: 2,000 psi, minimum.
      e. Thermal Coefficient of Expansion, ASTM D 696: Matrix material shall develop a coefficient of thermal expansion no greater than 10×10^{-6}.
      f. Linear Shrinkage, ASTM C 157/C 157M: 0.05 percent maximum in 365 days.
      g. Toxicity: Materials shall be non-toxic and non-allergenic and shall emit no toxic or noxious fumes or odors during mixing and placing procedures.

2. Polyester Terrazzo Flooring: Provide the following physical properties in the finished terrazzo flooring system:
   a. Compressive Strength, ASTM C 579: 8,000 psi, minimum.
   b. Bond Strength, ACI 403 Bulletin Title No. 59-43: 100 percent concrete failure, and 200 psi minimum tensile strength.
   c. Chemical Resistance, ASTM C 267: No evidence of change in color, blistering, cracking, peeling or loss of adhesion after 48 hours.
   d. Hardness, ASTM D 2240: 80, minimum.
   e. Water Absorption After 24 Hours, ASTM D 570: 0.10 percent, maximum.
   f. Porosity After 24 Hours, ASTM D 570: Eight percent maximum weight gain with no evidence of cracking, peeling, blistering or loss of adhesion.
   g. Flammability, ASTM D 635: Self-extinguishing.
3. Epoxy Terrazzo Flooring: Provide the following physical properties in the finished terrazzo flooring system:
   a. Compressive Strength, ASTM C 695: 10,000 psi, minimum.
   b. Bond Strength, ACI 403 Bulletin Title No. 59-43: 100 percent concrete failure, and 200 psi minimum tensile strength.
   c. Chemical Resistance - Seven-Day Immersion at Room Temperature, ASTM C 1308: No deleterious effect from the following:
      1) Isopropanol.
      2) Thirty percent sulfuric acid.
      3) Ten percent hydrochloric acid.
   d. Hardness, ASTM D 2240: 60 to 85.
   e. Porosity After 24 Hours, ASTM D 570: Eight percent maximum weight gain with no evidence of cracking, peeling, blistering or loss of adhesion.
   f. Flammability, ASTM D 635: Self-extinguishing.
   g. Thermal Coefficient of Linear Expansion, ASTM D 696: 25 x 10^{-6} in/in/°F maximum, over temperature range -12 to 140°F.

2.2 MANUFACTURERS

A. Polyacrylate Modified Portland Cement Matrix:
   1. Products and Manufacturers: Provide one of the following:
      a. Deco-Rez Thinset Polyacrylate No. 801 Terrazzo, as manufactured by General Polymers Corporation.
      b. Or equal.

B. Polyester Resin Matrix:
   1. Products and Manufacturers: Provide one of the following:
      a. Deco-Rez Thinset Polyester Terrazzo No. 1200, as manufactured by General Polymer Corporation.
      b. Or equal.

C. Epoxy Resin Matrix:
   1. Products and Manufacturers: Provide one of the following:

a. Deco-Rez Thinset Epoxy Terrazzo No. 1100, as manufactured by General Polymers Corporation.
b. Or equal.

D. Terrazzo Flooring Divider Strips and Similar Accessories:
1. Provide a complete selection of terrazzo flooring divider strips and other accessories.
2. Products and Manufacturers: Provide one of the following:
a. Dividing Strips, as manufactured by Manhattan American Terrazzo Strip Company.
b. Or equal.

2.3 MATERIALS

A. Acrylic Modified Portland Cement Matrix: Composite thin-set, complying with NTMA "Guide Specifications for Polyacrylate Terrazzo" and as required to match NTMA specified plate numbers specified.

B. Polyester Resin Matrix: Two-component polyester resin and hardener, mineral filler and color pigment, complying with NTMA "Guide Specifications for Polyester Terrazzo" and as required, to match NTMA plate number specified.

C. Epoxy Resin Matrix: Thermosetting, amine-cured epoxy resin and hardener, mineral filler and color pigment, complying with NTMA "Guide Specifications for Epoxy Terrazzo" and as required to match NTMA plate number specified.

D. White Portland Cement:
1. ASTM C 150, Type I.
2. Provide non-staining white portland cement, which will attain a compressive strength of not less than 2,800 pounds per square inch at three days and 4,000 pounds per square inch at seven days.
3. Products and Manufacturers: Provide one of the following:
a. Lehigh White Portland Cement by Lehigh Portland Cement Company.
b. Or equal.

E. Aggregates: Natural, sound, No. 2 and No. 1 crushed marble chips with a dust content of less than one percent by weight, colors selected and graded to match specified NTMA plate number and selected to avoid off-color or contaminated material, crushed by a process that will largely eliminate flat or slivery chips and accurately sized to yield marble chips for terrazzo, but with maximum size within limits of workability for the terrazzo thickness specified. Abrasion resistance of marble chips shall be Ha-10 minimum, in compliance with ASTM C 241, and shall have a 24-hour water absorption rate of less than 0.75 percent.

F. Matrix Pigments: Pure mineral pigments, alkali-resistant, color stable and compatible with matrix binder.

G. Sand: ASTM C 33; white.

H. Substrate Primer: Two-component resin or other compound recommended by matrix manufacturer, to penetrate and seal substrate and provide maximum bond of terrazzo to underbed.

I. Underbed to Cast-In-Place Concrete Slab Bonding Agent: Neat portland cement.

J. Finishing Grout: Cementitious or resin grout with filler and pigments, as recommended by matrix manufacturer.

K. Underlayment and Leveling Compound: Polyacrylate as recommended by terrazzo flooring manufacturer.

L. Terrazzo Cleaner: Provide a non-ionic, neutral detergent solution, free from crystallizing salts and water-soluble alkaline salts and which is biodegradable and phosphate free.

M. Penetrating Solvent Sealer: Polysiloxane penetrant sealer as recommended by the bonded cementitious terrazzo installer and as accepted by ENGINEER.

N. Finish Sealer: A modified acrylic compound recommended by matrix manufacturer, which is self-polishing and slip-resistant.

O. Acid Neutralizer: Dilute hydrochloric or phosphoric acid as acceptable to matrix manufacturer.

P. Curing Material: Water, wet sand or polyethylene sheeting.

Q. Water: Clean, free of oil, soluble salts and potable.

2.4 TERRAZZO ACCESSORIES

A. Divider Strips: Provide two-piece, zinc-coated steel "T-strips" with a 14-gauge vertical leg and heavy top strip of solid White Alloy Zinc. Provide an exposed face in the floor of 1/4-inch; depth of strips sized for depth of finished terrazzo flooring and type of terrazzo flooring system specified.

B. Accessory Strips: Match width, materials and color of floor divider strips, unless otherwise indicated. Provide the following types of accessory strips as required for a complete installation.
   1. One-piece base bead and 1-inch radii cove base dividers, to align with floor dividers, unless otherwise shown.
   2. Channels to receive abrasive inserts at stair treads and other locations shown.
   3. Stair nosings for treads, landings and similar exposed edges of flooring.

C. Angle-Type Strip: Solid white alloy zinc with 1/4-inch exposed thickness; depth of strips sized for depth of finished terrazzo flooring and type of terrazzo flooring system specified.

D. Abrasive Inserts: Composition strips, consisting of fused aluminum oxide or silicon carbide, with an amine-cured epoxy binder.

E. Control Strips Double or Split Units: Back-to-back 16-gauge angles, of same material and color as divider strip top.

F. Expansion Strips: T-type polyurethane filled expansion strips with white alloy zinc vertical legs; polyurethane exposed width of 1/4-inch with polyurethane full depth of strip; depth of strips sized for depth of finished terrazzo flooring and type of terrazzo flooring system specified.

G. Strip Adhesive: Two-component resin adhesive with mineral filler as recommended by the matrix manufacturer.

2.5 MIXES

A. Terrazzo Flooring Topping: In accordance with matrix resin manufacturer's written recommendations, as accepted by ENGINEER.

2.6 MIXING

A. Terrazzo Flooring Topping: Charge and mix marble chips, filler and matrix resin in accordance with manufacturer's written and approved instructions.

PART 3 - EXECUTION

3.1 INSPECTION

A. CONTRACTOR shall examine the substrates and conditions under which terrazzo flooring Work is to be performed and notify ENGINEER, in writing, of unsatisfactory conditions. Do not proceed with the Work until unsatisfactory conditions have been corrected in a manner acceptable to ENGINEER.

3.2 PREPARATION

A. Fill and shot blast concrete substrate as may be required to achieve a uniformly textured level finished appearance on finished Work in compliance with allowable tolerances specified.

B. Shot Blasting and Acid Neutralization: All areas to receive the Work of this Section shall be given a shot blast finish, to ensure maximum terrazzo flooring adhesion. After shot blasting the substrate shall be neutralized using an acid solution and water cleanup acceptable to the matrix resin manufacturer.

C. Prior to start of applying terrazzo flooring, broom clean or vacuum surfaces to be covered and inspect the subfloor. Start of application operations will indicate

acceptance of subfloor conditions as adequate to produce acceptable terrazzo flooring system in compliance with the requirements of this Section.

D. Apply substrate bonding agent in accordance with matrix manufacturer's written and approved instructions.

3.3 INSTALLATION

A. Comply with NTMA guide specifications for proportioning mixes, installation of strips, and for placing, curing, grinding, grouting and finishing, except as otherwise specified herein.

B. Provide terrazzo flooring shown or scheduled, without interruption or seams, except where divider, control joint stripes, or expansion joint strips are shown, or required.

C. Place and finish terrazzo flooring around permanently fixed-in-place obstructions and beneath all moveable furniture and equipment such as office files, laboratory furniture, lockers and similar equipment and furniture, to achieve continuous color, pattern and finish.

D. Install divider and accessory strips in a 3 foot-0 inches square maximum grid pattern with a 12-inch wide border along the base of all walls and as shown. Install in an adhesive setting bed, in accordance with manufacturer's instructions and without voids below strips. Provide mechanical anchorage for additional attachment of strips to substrate.

E. Provide control joints, where shown or required, by installing angle-type divider strips back-to-back.

F. Provide for expansion joints, where shown or required, by installing L-type divider strips back-to-back, with polyurethane filler of the width shown, but not less than 1/4-inch wide between strips.

G. Install abrasive inserts where shown and in accordance with insert manufacturer's approved instructions.

H. Mix, place and cure matrix and aggregates in accordance with matrix manufacturer's and NTMA approved standards. Comply with time limitations and instructions for rolling, troweling, sprinkling additional aggregates and curing installed Work.

I. Rough grind with 24 or finer grit stones. Follow initial grind with 80 or finer grit stones. Clean terrazzo flooring with clean water and rinse.

J. Remove excess rinse water and hand-apply grout using identical portland cement and color pigments as used in topping. Fill all voids and cure grout in compliance with matrix manufacturer's and NTMA approved instructions.

K. Grind with not less than 120-fine grit polishing stones, until all grout is removed from surface. Clean, rinse and apply penetrant sealer. Final grind with 800-fine grit size polishing stones. Clean floor thoroughly again, before applying final sealer coats. Exercise extreme care to ensure that fluids from grinding operation do not react with divider or control strips to produce a stain on aggregate.

3.4 FIELD QUALITY CONTROL

A. Allowable Tolerances:
   1. Prepared substrates shall be level with maximum variation not to exceed 1/8-inch in ten feet and shall have a finely textured surface achieved by shot blasting.
   2. Finished Floor Flatness: 1/8-inch in ten feet.
   3. Minimum Marble Chip Density: 70 percent minimum exposure upon completion of Work.

3.5 PROTECTION

A. Protect terrazzo flooring from damage until construction operations are completed and acceptable to ENGINEER.

B. Only the installer of terrazzo flooring shall be allowed in the installation area during the Work. No other installers or contractors shall be permitted to cross the Work area at any time during the installation of terrazzo flooring. Maintain appropriate barriers and signs alerting other trades during the times of restricted access.

C. Terrazzo flooring shall be protected from all damage and abuse from all other contractors and installers involved in the Project until final acceptance by OWNER. All floor surfaces shall be protected from abrasion or the adherence of any foreign material by maintaining rigid covers when necessary. The wheeling of materials or placement of concentrated loads shall not be allowed on finished floors.

3.6 ADJUSTMENT AND CLEANING

A. Thoroughly wash all surfaces with a neutral cleaner after fine grinding.

B. Rinse with clean water and allow surface to dry thoroughly.

C. Seal surface of terrazzo flooring with finish sealer in accordance with matrix manufacturer's and sealer manufacturer's approved instructions, after thoroughly curing and cleaning finished surface. Provide a two-coat final acrylic sealer application in strict compliance with sealer manufacturer's approved written requirements for a high gloss finish.

D. Remove damaged material and replaced with new. Remove all material between divider strips and other natural breaks in the Work and replace with new matching material in compliance with this Section.

E. Additional Final Cleaning: Clean terrazzo flooring and machine buff as required when building is ready for occupancy.

+ + END OF SECTION + +

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SECTION 09 91 00

PAINTING

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK

A. Provide all labor, materials, equipment and services for furnishing and installing the finishes as indicated on drawings and schedules, and as herein specified.

B. Work includes painting and finishing of interior and exterior exposed items and surfaces throughout project, except as otherwise indicated. Surface preparation, priming and coats of paint specified are in addition to shop-priming and surface treatment specified under other sections of work.

C. Work includes field painting of exposed bare and covered pipes and ducts (including color coding), and of hangers, exposed steel and iron work, and primed metal surfaces of equipment installed under mechanical and electrical work, except as otherwise indicated. In addition, the Contractor shall provide for the use of deep tone colors to be applied in selected areas as wall graphics, stripes and visual accents. The areas and colors shall be selected by the Architect-Engineer and shall not exceed 15% of the total wall surface area to be painted.

D. "Paint" as used herein means all coating systems materials, including primers, emulsions, enamels, stains, sealers and fillers, and other applied materials whether used as prime, intermediate or finish coats.

E. Surfaces to be Painted: Except where natural finish of material is specifically noted as a surface not to be painted, paint exposed surfaces whether or not colors are designated in "schedules". Where items or surfaces are not specifically mentioned, paint the same as similar adjacent materials or areas. If color or finish is not designated, Architect-Engineer will select these from standard colors or finishes available.

F. Following categories of work are not included as part of field- applied finish work.
   1. Pre-Finished Items: Unless otherwise indicated, do not include painting when factory-finishing or installer-finishing is specified for such items as (but not limited to) toilet enclosures, prefinished partition systems, acoustic materials, architectural woodwork and casework, and finish mechanical and electrical equipment, including light fixtures, switchgear, and distribution cabinets.

2. Concealed Surfaces: Unless otherwise indicated, painting is not required on surfaces such as walls or ceilings in concealed areas and generally inaccessible areas, furred areas, pipe spaces, and duct shafts.
3. Finished Metal Surfaces: Unless otherwise indicated, metal surfaces of anodized aluminum, stainless steel, chromium plate, copper, bronze and similar finished materials will not require finish painting.
4. Operating Parts: Unless otherwise indicated, moving parts of operating units, mechanical and electrical parts, such as valve and damper operators, linkages, sinkages, sensing devices, motor and fan shafts will not require finish painting.

G. Following categories of work are included under other sections of these specifications.
1. Shop Priming: Unless otherwise specified, shop priming of ferrous metal items is included under various sections for structural steel, metal fabrications, hollow metal work and similar items.
2. Unless otherwise specified, shop priming of fabricated components such as architectural woodwork, wood casework and shop-fabricated or factory-built mechanical and electrical equipment or accessories is included under other sections of these Specifications.

H. Do not paint over any code-required labels, such as Underwriters' Laboratories and Factory Mutual, or any equipment identification, performance rating, name, or nomenclature plates.

I. PVC plastic process piping shall not be painted, but shall be stenciled and labeled or tagged for identification surfaces. Each type of process piping using PVC pipe shall be installed using the same color pipe.

J. Repainting of existing structures, tanks, piping, and all other existing items shall not be part of this Contract unless otherwise noted. Areas that have been directly altered or damaged by construction shall be repainted to match existing conditions using the appropriate painting system.

1.2 RELATED DOCUMENTS

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

1.3 SUBMITTALS

A. Product Data: Submit manufacturer's technical information including paint label analysis and application instructions for each material proposed for use.

B. Samples: Prior to beginning work, submit color chips for surfaces to be painted. Use representative colors when preparing samples for review. Submit samples for Architect-Engineer's review of color and texture only. Provide a listing of material and application for each coat of each finish sample.

1.4 QUALITY ASSURANCE

A. Single Source Responsibility: Provide primers and other undercoat paint produced by same manufacturer as finish coats. Use only thinners approved by paint manufacturer, and use only within recommended limits.

B. Coordination of Work: Review other sections of these Specifications in which prime paints are to be provided to ensure compatibility of total coatings systems for various substrates. Upon request from other trades, furnish information or characteristics of finish materials provided for use, to ensure compatible prime coats are used.

1.5 DELIVERY AND STORAGE

A. Deliver materials to job site in original, new and unopened packages and containers bearing manufacturer's name and label, and following information:
   1. Name or title of material.
   2. Fed. Spec. number, if applicable.
   3. Manufacturer's stock number, batch number, and date of manufacturer.
   4. Manufacturer's name.
   5. Contents by volume, for major pigment and vehicle constituents.
   6. Thinning instructions.
   7. Application instructions.
   8. Color name and number.

B. Store materials not in actual use in tightly covered containers. Maintain containers used in storage of paint in a clean condition, free of foreign materials and residue. Protect from freezing where necessary. Keep storage area neat and orderly. Remove oily rags and waste daily. Take all precautions to ensure that workmen and work areas are adequately protected from fire hazards and health hazards resulting from handling, mixing and application of paints.

1.6 JOB CONDITIONS

A. Apply water-base paints only when temperature of surfaces to be painted and surrounding air temperatures are between 50 degrees F (10 degrees C) and 90 degrees F (32 degrees C), unless otherwise permitted or restricted by paint manufacturer's printed instructions.

B. Apply solvent-thinned paints only when temperature of surfaces to be painted and surrounding air temperatures are between 45 degrees F (7 degrees C) and 95

degrees F (35 degrees C), unless otherwise permitted or restricted by paint manufacturer's printed instructions.

C. Do not apply paint in snow, rain, fog or mist, or when relative humidity exceeds 85%, or to damp or wet surfaces, unless otherwise permitted or restricted by paint manufacturer's printed instructions. Painting may be continued during inclement weather if areas and surfaces to be painted are enclosed and heated within temperature limits specified by paint manufacturer during application and drying periods.

D. Paint only when the surface temperature is at least 5 degrees F above the dew point, unless otherwise permitted by paint manufacturer's printed instructions.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products which may be incorporated in the work include, but are not limited to, the following:
   1. Tnemec Company, Inc. (Tnemec)
   2. The Sherwin-Williams Company
   3. Carboline

2.2 MATERIALS

A. Material Quality: Provide best quality grade of various types of coatings as regularly manufactured by acceptable paint materials manufacturers. Materials not displaying manufacturer's identification as a standard, best-grade product will not be acceptable.

B. Proprietary names used to designate colors or materials are not intended to imply that products of named manufacturers are required to exclusion of equivalent products of other manufacturers.

C. Color Pigments: Pure, non-fading, applicable types to suit substrates and service indicated.
   1. Lead content in pigment, if any, is limited to contain not more than 0.06% lead, as lead metal based on the total non-volatile (dry-film) of paint by weight.

PART 3 - EXECUTION

3.1 INSPECTION

A. Applicator must examine areas and conditions under which painting work is to be applied and notify Contractor in writing of conditions detrimental to proper and timely completion of work. Do not proceed with work until unsatisfactory conditions have been corrected in a manner acceptable to Applicator.

B. Starting of painting work will be construed as Applicator's acceptance of surfaces and conditions within any particular area.

C. Do not paint over dirt, rust, scale, grease, moisture, scuffed surfaces, or conditions otherwise detrimental to formation of a durable paint film.

3.2 SURFACE PREPARATION

A. General: Perform preparation and cleaning procedures in accordance with paint manufacturer's instructions and as herein specified, for each particular substrate condition.
   1. Provide barrier coats over incompatible primers or remove and re-prime as required. Notify Architect-Architect-Engineer in writing of any anticipated problems in using the specified coating systems with substrates primed by others.
   2. Remove hardware, hardware accessories, machined surfaces, plates, lighting fixtures, and similar items in place and not to be finish-painted, or provide surface-applied protection prior to surface preparation and painting operations. Remove, if necessary, for complete painting of items and adjacent surfaces. Following completion of painting of each space or area, reinstall removed items.
   3. Clean surfaces to be painted before applying paint or surface treatments. Remove oil and grease prior to mechanical cleaning per SSPC SP-1. Program cleaning and painting so that contaminants from cleaning process will not fall onto wet, newly-painted surfaces.
   4. Abrasives for blasting shall be sharp, washed, salt free, angular, and free from feldspar or other constituents that tend to breakdown and remain on the surface.
   5. Concrete floors shall be dry as indicated by testing in accordance with ASTM D4263, Standard Test Method for Indicating Moisture in Concrete by the Plastic Sheet Method.

B. Cementitious Materials: Per ASTM D4261, Standard Practice for Surface Cleaning Concrete Unit Masonry for Coating, prepare cementitious surfaces of concrete block to be painted by removing efflorescence, chalk, dust, dirt, grease, oils, and by roughening as required to remove glaze. Per ASTM D4262, Standard Test Method for pH of Chemically Cleaned or Etched Concrete Surfaces, determine alkalinity of surfaces to be painted by performing appropriate tests. If surfaces are found to be sufficiently alkaline to cause blistering and burning of finish paint, correct this condition before application of paint. Test the surface for

moisture and do not paint over surfaces where moisture content exceeds that permitted in manufacturer's printed directions.

C. Wood: Clean wood surfaces to be painted of dirt, oil, or other foreign substances with scrapers, mineral spirits, and sandpaper, as required. Sandpaper smooth those finished surfaces exposed to view, and dust off. Scrape and clean small, dry, seasoned knots and apply a thin coat of white shellac or other recommended knot sealer, before application of priming coat. After priming, fill holes and imperfections in finish surfaces with putty or plastic wood-filler. Sandpaper smooth when dried.
   1. Prime, stain, or seal wood required to be job-painted immediately upon delivery to job. Prime edges, ends, faces, undersides, and backsides of such wood, including cabinets, counters, cases, paneling.
   2. When transparent finish is required, use spar varnish for backpriming.

D. Ferrous Metals: Clean ferrous surfaces, which are not galvanized or shop-coated, of oil, grease, dirt, and other foreign substances by solvent cleaning per SSPC SP-1. Mechanical cleaning shall be in accordance with SSPC-SP6 Commercial Blast Cleaning specifications for non-immersion surfaces and SSPC-SP10 Near White Metal Blast Cleaning for immersion in potable or non-potable water.

E. Galvanized Surfaces: Clean free of oil and surface contaminants with non-petroleum based solvent.

F. Shop Primed Surfaces: Prepare shop-applied prime coats wherever damaged or bare as required by other sections of these Specifications. Clean and touch-up with same type shop primer.

3.3 MATERIALS PREPARATION

A. Mix and prepare painting materials in accordance with manufacturer's directions.

B. Maintain containers used in mixing and application of paint in a clean condition, free of foreign materials and residue.

C. Stir materials before application to produce a mixture of uniform density, and stir as required during application. Do not stir surface film into material. Remove film and, if necessary, strain material before using.

3.4 APPLICATION

A. General: Apply paint in accordance with manufacturer's directions. Use applicators and techniques best suited for substrate and type of material being applied.

1. Painting requirements, surface treatments, and finishes, are indicated in "schedules" of the contract documents and as noted in Paragraph 3.11 hereinafter.
2. Provide finish coats which are compatible with prime paints used.
3. Apply additional coats when undercoats, stains or other conditions show through final coat of paint, until paint film is of uniform finish, color and appearance. Give special attention to insure that surfaces, including edges, corners, crevices, welds, and exposed fasteners receive a dry film thickness equivalent to that of flat surfaces.
4. Paint surfaces behind movable equipment and furniture same as similar exposed surfaces. Paint surfaces behind permanently- fixed equipment or furniture with prime coat only before final installation of equipment.
5. Paint interior surfaces of ducts, where visible through registers or grilles, with a flat, non-specular black paint.
6. Paint back sides of access panels, and removable or hinged covers to match exposed surfaces.
7. Finish exterior doors on tops, bottoms and side edges same as exterior faces, unless otherwise indicated.
8. Sand lightly between each succeeding enamel or varnish coat.
9. Omit first coat (primer) on metal surfaces which have been shop-primed and touch-up painted, unless otherwise indicated.

B. Scheduling Painting: Apply first-coat material to surfaces that have been cleaned, pretreated or otherwise prepared for painting as soon as practicable after preparation and before subsequent surface deterioration. Allow sufficient time between successive coatings to permit proper drying. Do not recoat until paint has dried to where it feels firm, does not deform or feel sticky under moderate thumb pressure, and application of another coat of paint does not cause lifting or loss of adhesion of the undercoat.

C. Minimum Coating Thickness: Apply materials at not less than manufacturer's recommended spreading rate, to establish a total dry film thickness as indicated or, if not indicated, as recommended by coating manufacturer. NOTE: PA-2 is only for large flat surfaces.

D. Mechanical and Electrical Work: Painting of mechanical and electrical work is limited to those items exposed in mechanical equipment rooms and in occupied spaces.
   1. Mechanical items to be painted include, but are not limited to, the following:
      a. Piping, pipe hangers, supplementary steel and supports except galvanized surfaces.
      b. Heat exchangers.
      c. Tanks.
      d. Ductwork, insulation.
      e. Motor, mechanical equipment, and supports.
      f. Accessory items.

2. Electrical items to be painted include, but are not limited to, the following:
   a. Conduits and fittings except galvanized surfaces.
   b. Switchgear (touch up only).
   c. Hanger and support except galvanized surfaces.

E. Prime Coats: Apply prime coat of material which is required to be painted or finished, and which has not been prime coated by others. Recoat primed and sealed surfaces where there is evidence of suction spots or unsealed areas in first coat, to assure a finish coat with no burn- through or other defects due to insufficient sealing.

F. Pigmented (Opaque) Finishes: Completely cover to provide an opaque, smooth surface of uniform finish, color, appearance and coverage. Cloudiness, spotting, holidays, laps, brush marks, runs, sags, ropiness or other surface imperfections will not be acceptable. Holiday test coated steel in immersion areas in accordance with NACE International SP0188-2007 Discontinuity (Holiday) Testing of New Protective Coatings on Conductive Substrates.

G. Transparent (Clear) Finishes: Use multiple coats to produce glass-smooth surface film of even luster. Provide a finish free of laps, cloudiness, color irregularity, runs, brush marks, orange peel, nail holes, or other surface imperfections. Provide satin finish for final coats, unless otherwise indicated.

H. Completed Work: Match approved samples for color, texture and coverage. Remove, refinish or repaint work not in compliance with specified requirements.

3.5 FIELD QUALITY CONTROL

A. The right is reserved by Owner to invoke the following material testing procedure at any time, and any number of times during period of field painting:
   1. Owner will engage services of an independent testing laboratory to sample paint being used. Samples of materials delivered to project site will be taken, identified and sealed, and certified in presence of Contractor.
   2. Testing laboratory will perform appropriate tests for any or all of following characteristics: Abrasion resistance, apparent reflectivity, flexibility, washability, absorption, accelerated weathering, dry opacity, accelerated yellowness, recoating, skinning, color retention, alkali resistance and quantitative materials analysis.

B. If test results show that material being used does not comply with specified requirements, Contractor may be directed to stop painting work, and remove non-complying paint; pay for testing; repaint surfaces coated with rejected paint; remove rejected paint from previously painted surfaces if, upon repainting with specified paint, the two coatings are non-compatible.

3.6 CLEAN-UP AND PROTECTION

A. Clean-Up: During progress of work, remove from site discarded paint materials, rubbish, cans and rags at end of each work day.

B. Upon completion of painting work, clean window glass and other paint-spattered surfaces. Remove spattered paint by proper methods of washing and scraping, using care not to scratch or otherwise damage finished surfaces.

C. Protection: Protect work of other trades, whether to be painted or not, against damage by painting and finishing work. Correct any damage by cleaning, repairing or replacing, and repainting, as acceptable to Architect-Architect-Engineer. Provide "Wet Paint" signs as required to protect newly-painted finishes. Remove temporary protective wrappings provided by others for protection of their work, after completion of painting operations. At completion of work of other trades, touch-up and restore all damaged or defaced painted surfaces.

3.7 PAINTING SYSTEMS

A. Ferrous Metals, Structural, Tanks, Pipe and Equipment

1. Exterior, Non-Immersion

	Tnemec	Dry Mils	Sherwin Williams	Dry Mils	Carboline	Dry Mils
Surface Prep	SSPC-SP6 Commercial Blast Cleaning		SSPC-SP6 Commercial Blast Cleaning		SSPC-SP6 Commercial Blast Cleaning	
1st Coat	91H20	2.5 – 3.5	Corothane I Galvapac NSF	2.5 – 3.5	Carbozinc 859	2.5 – 3.5
2nd Coat	N69 High-Build Epoxoline	4.0 – 6.0	Macropoxy 646	4.0 – 6.0	Carboguard 893 SG	4.0 – 6.0
3rd Coat	1074 Endura -Shield	2.0 – 3.0	Acrolon 218 HS	2.0 – 3.0	Carbothane 134 HG	2.0 – 3.0

2. Interior, Non-Immersion

	Tnemec	Dry Mils	Sherwin Williams	Dry Mils	Carboline	Dry Mils
Surface Prep	SSPC-SP6 Commercial Blast Cleaning		SSPC-SP6 Commercial Blast Cleaning		SSPC-SP6 Commercial Blast Cleaning	
1st Coat	91H20	2.5 – 3.5	Corothane I Galvapac NSF	2.5 – 3.5	Carbozinc 859	2.0 – 3.0
2nd Coat	N69 High-Build Epoxoline	4.0 – 6.0	Macropoxy 646	4.0 – 6.0	Carboguard 893 SG	4.0 – 6.0
3rd Coat	N69 High-Build Epoxoline	2.0 – 3.0	Macropoxy 646	2.0 – 3.0	Carboguard 893 SG	2.0 – 3.0

3. Immersion, Potable or Non-Potable Water

	Tnemec	Dry Mils	Sherwin Williams	Dry Mils	Carboline	Dry Mils
Surface Prep	SSPC-SP10 Near-White Blast Cleaning		SSPC-SP10 Near-White Blast Cleaning		SSPC-SP10 Near-White Blast Cleaning	
1st Coat	N140	4.0 –6.0	Macropoxy 646 PW	4.0 – 6.0	Carboguard 61	4.0 – 6.0
2nd Coat	N140	4.0 – 6.0	Macropoxy 646 PW	4.0 – 6.0	Carboguard 61	4.0 – 6.0
3rd Coat	N140	4.0 – 6.0	Macropoxy 646 PW	4.0 – 6.0	Carboguard 61	4.0 – 6.0

4. Factory Primed Interior (Refer to Piping Specifications)

	Tnemec	Dry Mils	Sherwin Williams	Dry Mils	Carboline	Dry Mils
Surface Prep	Surface Shall be Clean / Dry		Surface Shall be Clean / Dry		Surface Shall be Clean / Dry	
Touch up	N69 High-Build Epoxoline		Macropoxy 646		Carboguard 893 SG	
1st Coat	N69 High-Build Epoxoline	4.0 – 6.0	Macropoxy 646	4.0 – 6.0	Carboguard 893 SG	4.0 – 6.0
2nd Coat	N69 High-Build Epoxoline	4.0 – 6.0	Macropoxy 646	4.0 – 6.0	Carboguard 893 SG	4.0 – 6.0

5. Factory Primed, Exterior (Refer to Piping Specifications)

	Tnemec	Dry Mils	Sherwin Williams	Dry Mils	Carboline	Dry Mils
Surface Prep	Surface Shall be Clean / Dry		Surface Shall be Clean / Dry		Surface Shall be Clean / Dry	
Touch up	N69 Hi-Build Epoxoline		Macropoxy 646		Carboguard 893 SG	
1st Coat	N69 Hi-Build Epoxoline	4.0 – 6.0	Macropoxy 646	4.0 – 6.0	Carboguard 893 SG	4.0 – 6.0
2nd Coat	1074 Endura -Shield	2.0 – 3.0	Acrolon 218 HS, B65 Series	2.0 – 3.0	Carbothane 134 HG	2.0 – 3.0

6. Primed Steel (Doors, Frames, etc.) - Exterior

	Tnemec	Dry Mils	Sherwin Williams	Dry Mils	Carboline	Dry Mils
Surface Prep	Surface Shall be Clean / Dry		Surface Shall be Clean / Dry		Surface Shall be Clean / Dry	
Touch-up	N69 High-Build Epoxoline		Macropoxy 646		Carboguard 893 SG	
1st Coat	N 69 High-Build Epoxoline	4.0 – 6.0	Macropoxy 646	2.0 – 3.0	Carboguard 893 SG	4.0 – 6.0
2nd Coat	1074 Endura -Shield	2.0 – 3.0	Acrolon 218 HS	2.0 – 3.0	Carbothane 134 HG	2.0 – 3.0

7. Buried

	Tnemec	Dry Mils	Sherwin Williams	Dry Mils	Carboline	Dry Mils
Surface Prep	SSPC-SP6 Commercial Blast Cleaning		SSPC-SP6 Commercial Blast Cleaning		SSPC-SP6 Commercial Blast Cleaning	
1st Coat	Hi-Build Tneme-Tar	16.0 – 20.0	Hi-Mil Sher-Tar Epoxy	16.0 – 24.0	Bitumastic 300M	16.0 – 24.0

B. Galvanized Steel - Pipe and Miscellaneous Fabrications

1. Exterior, Non-Immersion

	Tnemec	Dry Mils	Sherwin Williams	Dry Mils	Carboline	Dry Mils
Surface Prep	SSPC-SP1 Solvent Cleaning		SSPC-SP1 Solvent Cleaning		SSPC-SP1 Solvent Cleaning	
1st Coat	N69 Hi-Build Epoxoline	4.0 – 6.0	Macropoxy 646	2.0 – 3.0	Carboguard 893 SG	4.0 – 6.0
2nd Coat	1074 Endura -Shield	2.0 – 3.0	Acrolon 218 HS	2.0 – 3.0	Carbothane 134 HG	2.0 – 3.0

2. Interior, Non-Immersion (Doors, Frames, etc.)

		Dry		Dry		Dry

	Tnemec	Mils	Sherwin Williams	Mils	Carboline	Mils
Surface Prep	SSPC-SP1 Solvent Cleaning		SSPC-SP1 Solvent Cleaning		SSPC-SP1 Solvent Cleaning	
1st Coat	N69 Hi-Build Epoxoline	4.0 – 6.0	Macropoxy 646	2.0 – 3.0	Carboguard 893 SG	4.0 – 6.0
2nd Coat	N69 Hi-Build Epoxoline	4.0 – 6.0	Macropoxy 646	2.0 – 3.0	Carboguard 893 SG	2.0 – 3.0

3. Immersion, Potable or Non-Potable Water

	Tnemec	Dry Mils	Sherwin Williams	Dry Mils	Carboline	Dry Mils
Surface Prep	SSPC-SP16 Brush-Off Blast Cleaning		SSPC-SP16 Brush-Off Blast Cleaning		SSPC-SP16 Brush-Off Blast Cleaning	
1st Coat	20-1255 Potapox	4.0 – 6.0	Macropoxy 646 NSF	4.0 – 6.0	Carboguard 61	4.0 – 6.0
2nd Coat	20-11 WH Potapox	4.0 – 6.0	Macropoxy 646 NSF	4.0 – 6.0	Carboguard 61	4.0 – 6.0

C. Porous Masonry - Concrete Masonry Units

1. Interior

	Tnemec	Dry Mils	Sherwin Williams	Dry Mils	Carboline	Dry Mils
Surface Prep	Surface Shall be Clean / Dry		Surface Shall be Clean / Dry		Surface Shall be Clean / Dry	
1st Coat	130 Envirofill (Spray and Back Roll to Fill Porosity)	80 - 100 sf/gal.	Pro-Industrial Hi-Bild Waterbased Catalyzed Epoxy	80-100 sf/gal	Carboline Sanitile 100	80 - 100 sf/gal
2nd Coat	113 H.B. Tneme-Tufcoat	2.0 – 3.0	Pro-Industrial Hi-Bild Waterbased Catalyzed Epoxy	2.0–3.0	Sanitile 255	2.0 – 3.0
3rd Coat	113 H.B. Tneme-Tufcoat	2.0 – 3.0	Pro-Industrial Hi-Bild Waterbased Catalyzed Epoxy	2.0–3.0	Sanitile 255	2.0 – 3.0

2. Exterior

	Tnemec	Dry Mils	Sherwin Williams	Dry Mils	Carboline	Dry Mils
Surface Prep	Surface Shall be Clean / Dry		Surface Shall be Clean / Dry		Surface Shall be Clean / Dry	
1st Coat	Series 156 Enviro-Crete	6.0 – 8.0*	Loxon XP	6.0-8.0*	Flexxide Elastomer	6.0 - 8.0*
2nd Coat	Series 156 Enviro-Crete	6.0 – 8.0*	Loxon XP	6.0-8.0*	Flexxide Elastomer	6.0 – 8.0*

*Coats must be sufficient to fill the porosity of the block face and create a pinhole-free surface.

D. Cast-In-Place Concrete

1. Concrete Walls & Precast Concrete Ceilings (Interior)

	Tnemec	Dry Mils	Sherwin Williams	Dry Mils	Carboline	Dry Mils
Surface Prep	SSPC-SP13 Abrasive Blast		SSPC-SP13 Abrasive Blast		SSPC-SP13 Abrasive Blast	
1st Coat	113 H.B. Tneme Tuf-coat	4.0–6.0	Pro-Industrial Hi-Bild Waterbased Catalyzed Epoxy	4.0 – 6.0	Sanitile 255	2.0 – 3.0
2nd Coat	113 H.B. Tneme Tuf-coat	4.0–6.0	Pro-Industrial Hi-Bild Waterbased Catalyzed Epoxy	4.0 – 6.0	Sanitile 255	2.0 – 3.0

2. Concrete Walls, Exterior & Non-Potable

	Tnemec	Dry Mils	Sherwin Williams	Dry Mils	Carboline	Dry Mils
Surface Prep	Surface Shall be Clean / Dry		Surface Shall be Clean / Dry		Surface Shall be Clean / Dry	

1st Coat	Series 156 Enviro-Crete	125 sf/gal	Loxon Masonry Primer	125 sf/gal	Flexxide Elastomere	125 sf/gal
2nd Coat	Series 156 Enviro-Crete	200 sf/gal	Loxon Masonry Coating	200 sf/gal	Flexxide Elastomere	200 sf/gal

3. Concrete Floors (Where noted on the drawings or specified)

	Tnemec	Dry Mils	Sherwin Williams	Dry Mils	Carboline	Dry Mils
Surface Prep	SSPC-SP13, Severe Service Abrasive Blast		SSPC-SP13, Severe Service Abrasive Blast		SSPC-SP13, Severe Service Abrasive Blast	
1st Coat	N 66 Epoxoline	3.0 – 5.0	Macropoxy 646	3.0 – 5.0	Carboguard 60	4.0 – 6.0
2nd Coat	N 66 Epoxoline	4.0 – 6.0	Macropoxy 646	4.0 – 6.0	Carboguard 60	4.0 – 6.0
3rd Coat	N 66 Epoxoline	4.0 – 6.0	Macropoxy 646	4.0 – 6.0	Carboguard 60	4.0 – 6.0

4. Concrete Tanks & Basins

	Tnemec	Dry Mils	Sherwin Williams	Dry Mils	Carboline	Dry Mils
Surface Prep	SSPC-SP13, Severe Service Abrasive Blast		SSPC-SP13, Severe Service Abrasive Blast		SSPC-SP13, Severe Service Abrasive Blast	
1st Coat	N140	4.0 – 6.0	Macropoxy 646 PW	4.0 – 6.0	Carboguard 61	4.0 – 6.0
2nd Coat	N140	4.0 – 6.0	Macropoxy 646PW	4.0 – 6.0	Carboguard 61	4.0 – 6.0
3rd Coat	N140	4.0 – 6.0	Macropoxy 646PW	4.0 – 6.0	Carboguard 61	4.0 – 6.0

5. a. Chemical Containment Areas – Acid Exposure

	Tnemec	Dry Mils	Sherwin Williams	Dry Mils	Carboline	Dry Mils
Surface Prep	SSPC-SP13, Severe Service Abrasive Blast		SSPC-SP13, Severe Service Abrasive Blast		SSPC-SP13, Severe Service Abrasive Blast	
1st Coat	Series 120-5002 Vinyl Ester	12 – 18	CoroBond Vinyl Ester Primer	3.5 – 4.0	Semstone 800	8.0 – 10.0
2nd Coat	Series 120-5002 Vinyl Ester	12 - 18	CorCote VEN FF	15.0 – 20.0	Semstone 870 (aggregate-filled)	25.0 – 30.0
3rd Coat			CorCote VEN FF with Wax Solution	15.0 – 20.0	Semstone 870	15.0 – 20.0

5. b. Chemical Containment Areas - Other

	Tnemec	Dry Mils	Sherwin Williams	Dry Mils	Carboline	Dry Mils
Surface Prep	SSPC-SP13, Severe Service Abrasive Blast		SSPC-SP13, Severe Service Abrasive Blast		SSPC-SP13, Severe Service Abrasive Blast	
1st Coat	201 Epoxoprime	6.0 – 8.0	CoroBond 100	6.0 – 8.0	Semstone 110	8.0 – 10.0
2nd Coat	275 Stranlock	25.0 – 40.0	CorCote HCR Flake-Filled	15.0 – 20.0	Semstone 145 SL	25 mils (Broadcast Silica)
3rd Coat	282 Tneme-Glaze	8.0 – 12.0	CorCote HCR	15.0 – 20.0	Semstone 145 SL	15.0 – 25.0

E. Wood - Interior or Exterior

	Tnemec	Dry Mils	Sherwin Williams	Dry Mils	Carboline	Dry Mils
Surface Prep	Surface Shall be Clean / Dry		Surface Shall be Clean / Dry		Surface Shall be Clean / Dry	

1st Coat	151-1051 Elasto-Grip FC	1.0 – 1.5	Multi-Purpose Latex Primer	1.0 – 1.5	Carbocrylic 120	1.0 – 2.0
2nd Coat	1029 Tufcryl	2.0–3.0 - 3.5	DTM Acrylic Coating	2.0 – 3.0	Carbocrylic 3359 DTM	2.0 – 3.0
3rd Coat	1029 Tufcryl	2.0 – 3.0	DTM Acrylic Coating	2.0 – 3.0	Carbocrylic 3359 DTM	2.0 – 3.0

F. Insulated Pipe

	Tnemec	**Dry Mils**	**Sherwin Williams**	**Dry Mils**	**Carboline**	**Dry Mils**
Surface Prep	Surface Shall be Clean / Dry		Surface Shall be Clean / Dry		Surface Shall be Clean / Dry	
1st Coat	1029Tneme-Cryl	2.0 – 3.0	DTM Primer/Finish, B66W1	2.0 – 3.0	Carbocrylic 120	1.0 – 2.0
2nd Coat	1029 Tneme-Cryl	2.0 – 3.0	DTM Primer/Finish, B66W1	2.0 – 3.0	Carbocrylic 3359 DTM	2.0 – 3.0

G. PVC Piping – See color coding below.

I. Aluminum Windows, Doors, Handrails & Grating – Do Not Paint

J. Fiberglass Reinforced Plastic Doors & Windows, Handrails & Grating – Do Not Paint

K. FRP panels, stainless steel panels, and instruments shall not be painted.

3.8 PIPING COLOR CODE

A. To facilitate identification of piping in plants and pumping stations it is recommended that the following color scheme be utilized:

WATER LINES	
Raw Water	Olive Green
Settled Water	Light Blue
Filtered, Finished or Potable Water	Dark Blue

CHEMICAL LINES	
Alum or Primary Coagulant (PACl)	Orange w/ green band
Ammonia	White
Carbon Slurry	Black
Caustic	Yellow w/ green band
Chlorine	Yellow
Copper Sulfate	Black w/ blue band
Corrosion Inhibitor (K-5)	Light green w/ red band
Lime Slurry	Light Green
Ferric Sulfate	Orange w/ black band
Fluoride	Light Blue w/ red band

Polymers or Coagulant Aid	Orange
Potassium Permanganate	Violet
Soda Ash	Light Green w/ orange band
Sodium Hypochlorite	Yellow w/ red band
Sulfur Dioxide	Light Green w/ yellow band
Other Chemical Lines	Yellow (stenciled as directed by CCA)
WASTE LINES	
Backwash Waste	Light Brown
Sewer (Sanitary or Other)	Dark Gray
Sludge	Dark Brown
OTHER	
Compressed Air	Dark Green
Gas	Red
Other Lines	Light Gray
Electrical Conduits & Junction Boxes	Orange (stenciled as directed by CCA)

B. All banding to be 2-inches wide and four feet on center.

C. Sample, drain, vent, metering, blowoff, decant, hot lines and all other pumps and equipment shall be painted the same color combination as the piping system from which the line originates unless specified otherwise above. The additional pertinent text shall be applied to the pipe.

D. Insulated pipe, jacketed with canvas, shall be painted with the color combination specified above.

E. Insulated pipe, jacketed with aluminum and/or stainless steel shall have the jacket unpainted. When valves and fittings for such lines are not insulated, the valves and fittings shall be color coded.

F. Building service lines such as plumbing lines, HVAC lines, and electrical conduit, shall not be color coded but shall be painted the same color as the background construction as directed CCA.

3.9 STENCILING

A. The Contractor shall supply all materials and labor necessary for stenciling of legends on pipes. The legend shall show the name of the contents. Review by the CCA of legends will be required. Names shall be "plainly visible" in all capital letters of approved size and type. Arrows showing direction of flow shall also be stenciled on pipes. The legends shall be applied on piping on every run and

located not more than 8 feet apart and, in general, at each valve and piece of equipment. The size and location of the legend shall be in general accordance with ANSI A13.1-1981 "Scheme for the Identification of Piping Systems". All visible piping 6" in diameter and larger shall be color-coded and stenciled. "Stick-on" labels are not acceptable.

B. Text shall be applied on piping in the middle of pipe runs for runs under 50 feet or in one room, whichever is the least distance. On runs greater than 50 feet, text shall be applied at third points in the run and no more than 35 feet apart.

3.10 PLASTIC IDENTIFICATION MARKERS

A. All visible piping 3/4" and greater and less than 6" which is accessible for maintenance operations shall be color-coded and identified with semi-rigid plastic identification markers equal to SETMARK Pipe Markers as manufactured by Seton Name Plate Corporation, New Haven, Conn.; T & B/Westline, Los Angeles, California; or equal. Direction of flow arrows are to be included on each marker, unless otherwise specified.

B. Each marker background is to be appropriately color coded with a clearly printed legend to identify the contents of the pipe in conformance with the "Scheme for the Identification of Piping Systems" (ANSI A 13.1 - 1981).

C. For pipes under 3/4" O.D. (too small for color bands and legends), brass identification tags 1-1/2" in diameter with depressed 1/4" high black-filled letters above 1/3" blackfilled numbers shall be fastened securely at specified locations.

D. All electrical conduits, which are accessible for maintenance operations, shall be identified with semi-rigid identification markers similar to those specified above.

E. Each marker background is to be color-coded with a clearly printed legend to identify the conductor. Size of markers and sizes of lettering to generally conform with the "Scheme for Identification of Piping Systems" (ANSI A 13.1 - 1981)

F. Locations for pipe and electrical markers to be as follows:
   1. Adjacent to each valve and fitting (except on plumbing fixtures and equipment).
   2. At each branch and riser take-off.
   3. At each pipe passage through wall, floor and ceiling construction.
   4. At each pipe passage to underground.
   5. On all horizontal pipe runs-marked every 25 feet.

3.11 PAINT SCHEDULE

All items at the Project site shall be painted in accordance with these Specifications and

Drawings. The following paint schedule is provided only to assist the Owner and Contractor in selection of the appropriate paint system and is not intended to be a complete list of items to be painted.

A. Paint Application Schedule

Location and/or Description	System
1. Tunnel	
a. Cast-in-Place Concrete	D
2. Filter Building Electrical Room	
a. Drywall Walls	G.2
b. Doors and Frames, Interior	B.2
c. Cast-In-Place Concrete	D
d. Equipment & Piping	A
3. Exhaust Fan Support Frame	
a. Miscellaneous Steel	A.2
4. Sedimentation Basins	
a. Rake Arm Structures (Alternative No. 4)	A.3

++ END OF SECTION ++

SECTION 10 14 00

SIGNAGE

PART 1 – GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes the following:
   1. Panel signs.

1.3 DEFINITIONS

A. ADA-ABA Accessibility Guidelines: U.S. Architectural & Transportation Barriers Compliance Board's "Americans with Disabilities Act (ADA) Accessibility Guidelines for Buildings and Facilities; Architectural Barriers Act (ABA) Accessibility Guidelines."

1.4 ACTION SUBMITTALS

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

B. Shop Drawings: Show fabrication and installation details for signs.
   1. Show sign mounting heights, locations of supplementary supports to be provided by others, and accessories.
   2. Provide message list, typestyles, graphic elements, including tactile characters and Braille, and layout for each sign.

C. Samples for Initial Selection: Manufacturer's color charts consisting of actual units or sections of units showing the full range of colors available for the following:
   1. Aluminum.
   2. Acrylic sheet.
   3. Polycarbonate sheet.
   4. Fiberglass sheet.
   5. Die-cut vinyl characters and graphic symbols. Include representative samples of available typestyles and graphic symbols.

D. Samples for Verification: For each of the following products and for the full range of color, texture, and sign material indicated, of sizes indicated:

1. One full size sign complete.

E. Sign Schedule: Use same designations indicated on Drawings.

1.5 INFORMATIONAL SUBMITTALS

A. Warranty: Special warranty specified in this Section.

1.6 CLOSEOUT SUBMITTALS

A. Maintenance Data: For signs to include in maintenance manuals.

1.7 QUALITY ASSURANCE

A. Installer Qualifications: Fabricator of products, an employer of workers trained and approved by manufacturer.

B. Fabricator Qualifications: Shop that employs skilled workers who custom-fabricate products similar to those required for this Project and whose products have a record of successful in-service performance.

C. Source Limitations for Signs: Obtain each sign type indicated from one source from a single manufacturer.

D. Regulatory Requirements: Comply with applicable provisions in ADA-ABA Accessibility Guidelines and ICC/ANSI A117.1.

E. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

1.8 PROJECT CONDITIONS

A. Weather Limitations: Proceed with installation only when existing and forecasted weather conditions permit installation of signs in exterior locations to be performed according to manufacturers' written instructions and warranty requirements.

B. Field Measurements: Verify recess openings by field measurements before fabrication and indicate measurements on Shop Drawings.

1.9 COORDINATION

A. Coordinate placement of anchorage devices with templates for installing signs.

1.10 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of signs that fail in materials or workmanship within specified warranty period.
   1. Failures include, but are not limited to, the following:
      a. Deterioration of metal and polymer finishes beyond normal weathering.
      b. Deterioration of embedded graphic image colors and sign lamination.
   2. Warranty Period: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Aluminum Castings: ASTM B 26/B 26M, of alloy and temper recommended by sign manufacturer for casting process used and for use and finish indicated.

B. Aluminum Sheet and Plate: ASTM B 209 (ASTM B 209M), alloy and temper recommended by aluminum producer and finisher for type of use and finish indicated, and with at least the strength and durability properties of Alloy 5005-H32.

C. Aluminum Extrusions: ASTM B 221 (ASTM B 221M), alloy and temper recommended by aluminum producer and finisher for type of use and finish indicated, and with at least the strength and durability properties of Alloy 6063-T5.

D. Brass Castings: ASTM B 584, Alloy UNS No. C85200 (high-copper yellow brass).

E. Brass, Yellow, Sheet: ASTM B 36/B 36M, Alloy UNS No. C26000.

F. Bronze Castings: ASTM B 584, Alloy UNS No. C86500 (No. 1 manganese bronze).

G. Bronze Plate: ASTM B 36/B 36M.

H. Copper Sheet: ASTM B 152/B 152M.

I. Steel:
   1. Galvanized Steel Sheet: ASTM A 653/A 653M, G90 (Z275) coating, either commercial or forming steel.
   2. Steel Sheet: Uncoated, cold-rolled, ASTM A 1008/A 1008M, commercial steel, Type B, exposed or electrolytic zinc-coated, ASTM A 591/A 591M, with steel sheet substrate complying with ASTM A 1008/A 1008M, commercial steel, exposed.

3. Stainless-Steel Sheet: ASTM A 240/A 240M or ASTM A 666, Type 304, 316, stretcher-leveled standard of flatness.
4. Steel Members Fabricated from Plate or Bar Stock: ASTM A 529/A 529M or ASTM A 572/A 572M, 42,000-psi (290-MPa) minimum yield strength.
5. For steel exposed to view on completion, provide materials having flat, smooth surfaces without blemishes. Do not use materials whose surfaces exhibit pitting, seam marks, roller marks, rolled trade names, or roughness.

J. Fiberglass Sheet: Molded, seamless, thermosetting, glass-fiber-reinforced polyester panels with a minimum tensile strength of 15,000 psi (103 MPa) when tested according to ASTM D 638 and with a minimum flexural strength of 30,000 psi (207 MPa) when tested according to ASTM D 790.

K. Acrylic Sheet: ASTM D 4802, Category A-1 (cell-cast sheet), Type UVA (UV absorbing).

L. Polycarbonate Sheet: Of thickness indicated, manufactured by extrusion process, coated on both surfaces with abrasion-resistant coating:
1. Impact Resistance: 16 ft-lbf/in. (854 J/m) per ASTM D 256, Method A.
2. Tensile Strength: 9000 lbf/sq. in. (62 MPa) per ASTM D 638.
3. Flexural Modulus of Elasticity: 340,000 lbf/sq. in. (2345 MPa) per ASTM D 790.
4. Heat Deflection: 265 deg F (129 deg C) at 264 lbf/sq. in. (1.82 MPa) per ASTM D 648.
5. Abrasion Resistance: 1.5 percent maximum haze increase for 100 revolutions of a Taber abraser with a load of 500 g per ASTM D 1044.

M. Applied Vinyl: Die-cut characters from vinyl film of nominal thickness of 3 mils (0.076 mm) with pressure-sensitive adhesive backing, suitable for exterior applications.

2.2 PANEL SIGNS

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

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. ACE Sign Systems, Inc.
2. Advance Corporation; Braille-Tac Division.
3. Allen Industries Architectural Signage
4. Allenite Signs; Allen Marking Products, Inc.
5. APCO Graphics, Inc.
6. ASI-Modulex, Inc.
7. Best Sign Systems Inc.

8. Bunting Graphics, Inc.
9. Fossil Industries, Inc.
10. Gemini Incorporated.
11. Grimco, Inc.
12. Innerface Sign Systems, Inc.
13. InPro Corporation
14. Matthews International Corporation; Bronze Division.
15. Mills Manufacturing Company.
16. Mohawk Sign Systems.
17. Nelson-Harkins Industries.
18. Seton Identification Products.
19. Signature Signs, Incorporated.
20. Supersine Company (The)
21. Equivalent by other manufacturer.

C. Interior Panel Signs: Provide smooth sign panel surfaces constructed to remain flat under installed conditions within a tolerance of plus or minus 1/16 inch (1.5 mm) measured diagonally from corner to corner, complying with the following requirements:
   1. Size: Minimum 8" x 8".
   2. Laminated, Etched Photopolymer: Raised graphics with Braille 1/32 inch (0.8 mm) above surface with contrasting colors as selected by Architect from manufacturer's full range and laminated to acrylic back.
   3. Edge Condition: Beveled.
   4. Corner Condition: Square.
   5. Mounting: Framed. Extruded aluminum mitired with concealed anchors and welded.
      a. Wall mounted with concealed anchors.
      b. Manufacturer's standard anchors for substrates encountered.
   6. Color: As selected by Architect from manufacturer's full range.
   7. Tactile Characters: Characters and Grade 2 Braille raised 1/32 inch (0.8 mm) above surface with contrasting colors.

D. Panel Sign Frames:
   1. Extruded-Aluminum Frames: Mitered with concealed anchors and welded.
      a. Color: As selected by Architect from manufacturer's full range.
      b. Depth: 1/2".
      c. Profile: Square.
      d. Corner Condition: Square.
      e. Mounting:
         1) Wall mounted with concealed anchors.
         2) Manufacturer's standard noncorroding anchors for substrates encountered.

E. Tactile and Braille Sign: Manufacturer's standard process for producing text and symbols complying with ADA-ABA Accessibility Guidelines and with

ICC/ANSI A117.1. Text shall be accompanied by Grade 2 Braille. Produce precisely formed characters with square-cut edges free from burrs and cut marks; Braille dots with domed or rounded shape.

1. Panel Material: Photopolymer.
2. Raised-Copy Thickness: Not less than 1/32 inch (0.8 mm).

F. Engraved Copy: Machine engrave letters, numbers, symbols, and other graphic devices into panel sign on face indicated to produce precisely formed copy, incised to uniform depth.
   1. Engraved Opaque Acrylic Sheet: Fill engraved copy with enamel.

G. Panel Sign Schedule:
   1. Provide signage for each room.
      a. Sign Size: 8" x 8".
      b. Message Panel Material: As specified.
      c. Message Panel Finish/Color: as selected by Owner.
      d. Background Finish/Color: As selected by Owner.
      e. Character Size: As required by ADA.
      f. Character Finish/Color: As selected by Owner.
      g. Panel Sign Frame Finish/Color: As selected by Owner.
      h. Text/Message: Room name and number.
      i. Location: At the latch side of each door at height required by the ADA.
      j. Provide International pictogram at restroom signs in addition to other requirements.

2.3 ACCESSORIES

A. Anchors and Inserts: Provide nonferrous-metal or hot-dip galvanized anchors and inserts for exterior installations and elsewhere as required for corrosion resistance. Use toothed steel or lead expansion-bolt devices for drilled-in-place anchors. Furnish inserts, as required, to be set into concrete or masonry work.

2.4 FABRICATION

A. General: Provide manufacturer's standard signs of configurations indicated.
   1. Welded Connections: Comply with AWS standards for recommended practices in shop welding. Provide welds behind finished surfaces without distortion or discoloration of exposed side. Clean exposed welded surfaces of welding flux and dress exposed and contact surfaces.
   2. Mill joints to tight, hairline fit. Form joints exposed to weather to exclude water penetration.
   3. Preassemble signs in the shop to greatest extent possible. Disassemble signs only as necessary for shipping and handling limitations. Clearly mark units for reassembly and installation, in location not exposed to view after final assembly.

4. Conceal fasteners if possible; otherwise, locate fasteners where they will be inconspicuous.

2.5 FINISHES, GENERAL

A. Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.

B. Protect mechanical finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.

C. Appearance of Finished Work: Variations in appearance of abutting or adjacent pieces are acceptable if they are within one-half of the range of approved Samples. Noticeable variations in the same piece are not acceptable. Variations in appearance of other components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.

2.6 ALUMINUM FINISHES

A. Clear Anodic Finish: Manufacturer's standard Class 1 clear anodic coating, 0.018 mm or thicker, over a satin (directionally textured) mechanical finish, complying with AAMA 611.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of work.

B. Verify that items, including anchor inserts, are sized and located to accommodate signs.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Locate signs and accessories where indicated, using mounting methods of types described and complying with manufacturer's written instructions.
   1. Install signs level, plumb, and at heights indicated, with sign surfaces free of distortion and other defects in appearance.
   2. Interior Wall Signs: Install signs on walls adjacent to latch side of door where applicable. Where not indicated or possible, such as double doors, install signs on nearest adjacent walls. Locate to allow approach within 3

inches (75 mm) of sign without encountering protruding objects or standing within swing of door.

B. Wall-Mounted Signs: Comply with sign manufacturer's written instructions except where more stringent requirements apply.
   1. Two-Face Tape: Mount signs to smooth, nonporous surfaces. Do not use this method for vinyl-covered or rough surfaces.
   2. Hook-and-Loop Tapes: Mount signs to smooth, nonporous surfaces.
   3. Magnetic Tape: Mount signs to smooth, nonporous surfaces.
   4. Silicone-Adhesive Mounting: Attach signs to irregular, porous, or vinyl-covered surfaces.
   5. Shim Plate Mounting: Provide 1/8-inch- (3-mm-) thick, concealed aluminum shim plates with predrilled and countersunk holes, at locations indicated, and where other mounting methods are not practicable. Attach plate with fasteners and anchors suitable for secure attachment to substrate. Attach panel signs to plate using method specified above.
   6. Mechanical Fasteners: Use nonremovable mechanical fasteners placed through predrilled holes. Attach signs with fasteners and anchors suitable for secure attachment to substrate as recommended in writing by sign manufacturer.
   7. Signs Mounted on Glass: Provide matching opaque plate on opposite side of glass to conceal mounting materials.

C. Bracket-Mounted Signs: Provide manufacturer's standard brackets, fittings, and hardware for mounting signs that project at right angles from walls and ceilings. Attach brackets and fittings securely to walls and ceilings with concealed fasteners and anchoring devices to comply with manufacturer's written instructions.

D. Dimensional Characters: Mount characters using standard fastening methods to comply with manufacturer's written instructions for character form, type of mounting, wall construction, and condition of exposure indicated. Provide heavy paper template to establish character spacing and to locate holes for fasteners.
   1. Flush Mounting: Mount characters with backs in contact with wall surface.
   2. Projected Mounting: Mount characters at projection distance from wall surface indicated.

E. Cast-Metal Plaques: Mount plaques using standard fastening methods to comply with manufacturer's written instructions for type of wall surface indicated.
   1. Concealed Mounting: Mount plaques by inserting threaded studs into tapped lugs on back of plaque. Set in predrilled holes filled with quick-setting cement.
   2. Face Mounting: Mount plaques using exposed fasteners with rosettes attached through face of plaque into wall surface.

3.3 CLEANING AND PROTECTION

A. After installation, clean soiled sign surfaces according to manufacturer's written instructions. Protect signs from damage until acceptance by Owner.

+ + END OF SECTION + +

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SECTION 23 00 00

COMMON WORK RESULTS FOR HVAC

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes the following:
   1. Dielectric fittings.
   2. Sleeves.
   3. Equipment installation requirements common to equipment sections.
   4. Painting and finishing.
   5. Supports and anchorages.

1.3 DEFINITIONS

A. Finished Spaces: Spaces other than mechanical and electrical equipment rooms, furred spaces, pipe and duct chases, unheated spaces immediately below roof, spaces above ceilings, unexcavated spaces, crawlspaces, and tunnels.

B. Exposed, Interior Installations: Exposed to view indoors. Examples include finished occupied spaces and mechanical equipment rooms.

C. Exposed, Exterior Installations: Exposed to view outdoors or subject to outdoor ambient temperatures and weather conditions. Examples include rooftop locations.

D. Concealed, Interior Installations: Concealed from view and protected from physical contact by building occupants. Examples include above ceilings and chases.

E. Concealed, Exterior Installations: Concealed from view and protected from weather conditions and physical contact by building occupants but subject to outdoor ambient temperatures. Examples include installations within unheated shelters.

F. The following are industry abbreviations for plastic materials:
   1. PVC: Polyvinyl chloride plastic.

G. The following are industry abbreviations for rubber materials:
   1. EPDM: Ethylene-propylene-diene terpolymer rubber.

2. NBR: Acrylonitrile-butadiene rubber.

1.4 SUBMITTALS

H. Product Data: For the following:
   1. Dielectric fittings.

I. Welding certificates.

1.5 QUALITY ASSURANCE

A. Steel Support Welding: Qualify processes and operators according to AWS D1.1, "Structural Welding Code--Steel."

B. Electrical Characteristics for HVAC Equipment: Equipment of higher electrical characteristics may be furnished provided such proposed equipment is approved in writing and connecting electrical services, circuit breakers, and conduit sizes are appropriately modified. If minimum energy ratings or efficiencies are specified, equipment shall comply with requirements.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Deliver pipes and tubes with factory-applied end caps. Maintain end caps through shipping, storage, and handling to prevent pipe end damage and to prevent entrance of dirt, debris, and moisture.

B. Store plastic pipes protected from direct sunlight. Support to prevent sagging and bending.

1.7 COORDINATION

A. Arrange for pipe spaces, chases, slots, and openings in building structure during progress of construction, to allow for HVAC installations.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. In other Part 2 articles where subparagraph titles below introduce lists, the following requirements apply for product selection:
   1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the manufacturers specified.

2. Manufacturers: Subject to compliance with requirements, provide products by the manufacturers specified.

2.2 PIPE, TUBE, AND FITTINGS

A. Refer to individual Division 40 piping Sections for pipe, tube, and fitting materials and joining methods.

B. Pipe Threads: ASME B1.20.1 for factory-threaded pipe and pipe fittings.

2.3 JOINING MATERIALS

A. Refer to individual Division 40 piping Sections for special joining materials not listed below.

B. Solder Filler Metals: ASTM B 32, lead-free alloys. Include water-flushable flux according to ASTM B 813.

C. Brazing Filler Metals: AWS A5.8, BCuP Series, copper-phosphorus alloys for general-duty brazing, unless otherwise indicated; and AWS A5.8, BAg1, silver alloy for refrigerant piping, unless otherwise indicated.

D. Welding Filler Metals: Comply with AWS D10.12 for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.

2.4 DIELECTRIC FITTINGS

A. Description: Combination fitting of copper alloy and ferrous materials with threaded, solder-joint, plain, or weld-neck end connections that match piping system materials.

B. Insulating Material: Suitable for system fluid, pressure, and temperature.

C. Dielectric Unions: Factory-fabricated, union assembly, for 250-psig minimum working pressure at 180 deg F.
   1. Manufacturers:
      a. Capitol Manufacturing Co.
      b. Central Plastics Company.
      c. Eclipse, Inc.
      d. Epco Sales, Inc.
      e. Hart Industries, International, Inc.
      f. Watts Industries, Inc.; Water Products Div.
      g. Zurn Industries, Inc.; Wilkins Div.

2.5 SLEEVES

A. PVC Pipe: ASTM D 1785, Schedule 40.

PART 3 - EXECUTION

3.1 PIPING SYSTEMS - COMMON REQUIREMENTS

A. Install piping according to the following requirements and Division 40 Sections specifying piping systems.

B. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.

C. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

D. Install piping to permit valve servicing.

E. Install piping at indicated slopes.

F. Install piping free of sags and bends.

G. Install fittings for changes in direction and branch connections.

H. Install piping to allow application of insulation.

I. Select system components with pressure rating equal to or greater than system operating pressure.

J. Sleeves are not required for core-drilled holes.

K. Permanent sleeves are not required for holes formed by removable PE sleeves.

L. Install sleeves for pipes passing through concrete and masonry walls and concrete floor and roof slabs.

M. Verify final equipment locations for roughing-in.

N. Refer to equipment specifications in other Sections of these Specifications for roughing-in requirements.

3.2 PIPING JOINT CONSTRUCTION

A. Join pipe and fittings according to the following requirements and Division 15 Sections specifying piping systems.

B. Ream ends of pipes and tubes and remove burrs.

C. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.

D. Soldered Joints: Apply ASTM B 813, water-flushable flux, unless otherwise indicated, to tube end. Construct joints according to ASTM B 828 or CDA's "Copper Tube Handbook," using lead-free solder alloy complying with ASTM B 32.

E. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," "Pipe and Tube" Chapter, using copper-phosphorus brazing filler metal complying with AWS A5.8.

F. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:

1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

3.3 EQUIPMENT INSTALLATION - COMMON REQUIREMENTS

A. Install equipment to allow maximum possible headroom unless specific mounting heights are not indicated.

B. Install equipment level and plumb, parallel and perpendicular to other building systems and components in exposed interior spaces, unless otherwise indicated.

C. Install HVAC equipment to facilitate service, maintenance, and repair or replacement of components. Connect equipment for ease of disconnecting, with minimum interference to other installations. Extend grease fittings to accessible locations.

D. Install equipment to allow right of way for piping installed at required slope.

3.4 PAINTING

A. Painting of HVAC systems, equipment, and components is specified in Division 9 Sections "Interior Painting" and "Exterior Painting."

B. Damage and Touchup: Repair marred and damaged factory-painted finishes with materials and procedures to match original factory finish.

3.5 ERECTION OF METAL SUPPORTS AND ANCHORAGES

A. Refer to Division 5 Section "Metal Fabrications" for structural steel.

B. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor HVAC materials and equipment.

C. Field Welding: Comply with AWS D1.1.

+ + END OF SECTION + +

SECTION 23 05 13

COMMON MOTOR REQUIREMENTS FOR HVAC EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes general requirements for single-phase and polyphase, general-purpose, horizontal, small and medium, squirrel-cage induction motors for use on ac power systems up to 600 V and installed at equipment manufacturer's factory or shipped separately by equipment manufacturer for field installation.

1.3 COORDINATION

A. Coordinate features of motors, installed units, and accessory devices to be compatible with the following:
   1. Motor controllers.
   2. Torque, speed, and horsepower requirements of the load.
   3. Ratings and characteristics of supply circuit and required control sequence.
   4. Ambient and environmental conditions of installation location.

PART 2 - PRODUCTS

2.1 GENERAL MOTOR REQUIREMENTS

A. Comply with requirements in this Section except when stricter requirements are specified in HVAC equipment schedules or Sections.
   1. Comply with NEMA MG 1 unless otherwise indicated.
   2. Comply with IEEE 841 for severe-duty motors.

2.2 MOTOR CHARACTERISTICS

A. Duty: Continuous duty at ambient temperature of 40 deg C and at altitude of 3300 feet (1000 m) above sea level.

B. Capacity and Torque Characteristics: Sufficient to start, accelerate, and operate connected loads at designated speeds, at installed altitude and environment, with indicated operating sequence, and without exceeding nameplate ratings or

considering service factor.

2.3 POLYPHASE MOTORS

A. Description: NEMA MG 1, Design B, medium induction motor.

B. Efficiency: Energy efficient, as defined in NEMA MG 1.

C. Service Factor: 1.15.

D. Rotor: Random-wound, squirrel cage.

E. Bearings: Regreasable, shielded, antifriction ball bearings suitable for radial and thrust loading.

F. Temperature Rise: Match insulation rating.

G. Insulation: Class F.

H. Code Letter Designation:
   1. Motors 15 HP and Larger: NEMA starting Code F or Code G.
   2. Motors Smaller than 15 HP: Manufacturer's standard starting characteristic.

I. Enclosure Material: Cast iron for motor frame sizes 324T and larger; rolled steel for motor frame sizes smaller than 324T.

2.4 SINGLE-PHASE MOTORS

A. Bearings: Prelubricated, antifriction ball bearings or sleeve bearings suitable for radial and thrust loading.

B. Motors 1/20 HP and Smaller: Shaded-pole type.

C. Thermal Protection: Internal protection to automatically open power supply circuit to motor when winding temperature exceeds a safe value calibrated to temperature rating of motor insulation. Thermal-protection device shall automatically reset when motor temperature returns to normal range.

PART 3 - EXECUTION (NOT USED)

+ + END OF SECTION + +

SECTION 23 05 29

HANGERS AND SUPPORTS FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:
   1. Metal pipe hangers and supports.

1.3 DEFINITIONS

A. MSS: Manufacturers Standardization Society of The Valve and Fittings Industry Inc.

1.4 INFORMATIONAL SUBMITTALS

A. Welding certificates.

1.7 QUALITY ASSURANCE

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

B. Pipe Welding Qualifications: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code.

PART 2 - PRODUCTS

2.1 METAL PIPE HANGERS AND SUPPORTS

A. Carbon-Steel Pipe Hangers and Supports:
   1. Description: MSS SP-58, Types 1 through 58, factory-fabricated components.
   2. Galvanized Metallic Coatings: Pregalvanized or hot dipped.
   3. Nonmetallic Coatings: Plastic coating, jacket, or liner.
   4 Hanger Rods: Continuous-thread rod, nuts, and washer made of stainless steel.

B. Copper Pipe Hangers:
   1. Description: MSS SP-58, Types 1 through 58, copper-coated-steel, factory-fabricated components.
   2. Hanger Rods: Continuous-thread rod, nuts, and washer made of copper-coated steel.

2.2 FASTENER SYSTEMS

A. Powder-Actuated Fasteners: Threaded-steel stud, for use in hardened portland cement concrete with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

B. Mechanical-Expansion Anchors: Insert-wedge-type, stainless-steel anchors, for use in hardened portland cement concrete; with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

2.3 EQUIPMENT SUPPORTS

A. Description: Welded, shop- or field-fabricated equipment support made from structural carbon-steel shapes.

2.4 MISCELLANEOUS MATERIALS

A. Structural Steel: ASTM A 36/A 36M, carbon-steel plates, shapes, and bars; black and galvanized.

PART 3 - EXECUTION

3.1 HANGER AND SUPPORT INSTALLATION

A. Metal Pipe-Hanger Installation: Comply with MSS SP-69 and MSS SP-89. Install hangers, supports, clamps, and attachments as required to properly support piping from the building structure.

B. Fastener System Installation:
   1. Install powder-actuated fasteners for use in lightweight concrete or concrete slabs less than 4 inches (100 mm) thick in concrete after concrete is placed and completely cured. Use operators that are licensed by powder-actuated tool manufacturer. Install fasteners according to powder-actuated tool manufacturer's operating manual.
   2. Install mechanical-expansion anchors in concrete after concrete is placed and completely cured. Install fasteners according to manufacturer's written instructions.

C. Install hangers and supports complete with necessary attachments, inserts, bolts, rods, nuts, washers and other accessories.

D. Install lateral bracing with pipe hangers and supports to prevent swaying.

E. Load Distribution: Install hangers and supports so that piping live and dead loads and stresses from movement will not be transmitted to connected equipment.

O. Pipe Slopes: Install hangers and supports to provide indicated pipe slopes and to not exceed maximum pipe deflections allowed by ASME B31.9 for building services piping.

P. Insulated Piping:
   1. Attach clamps and spacers to piping.
      a. Piping Operating above Ambient Air Temperature: Clamp may project through insulation.
   2. Install MSS SP-58, Type 39, protection saddles if insulation without vapor barrier is indicated. Fill interior voids with insulation that matches adjoining insulation.

3.2 EQUIPMENT SUPPORTS

A. Fabricate structural-steel stands to suspend equipment from structure overhead or to support equipment above floor.

B. Provide lateral bracing, to prevent swaying, for equipment supports.

3.3 METAL FABRICATIONS

A. Fit exposed connections together to form hairline joints. Field weld connections that cannot be shop welded because of shipping size limitations.

B. Field Welding: Comply with AWS D1.1/D1.1M procedures for shielded, metal arc welding; appearance and quality of welds; and methods used in correcting welding work; and with the following:
   1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
   2. Obtain fusion without undercut or overlap.
   3. Remove welding flux immediately.
   4. Finish welds at exposed connections so no roughness shows after finishing and so contours of welded surfaces match adjacent contours.

3.4 ADJUSTING

A. Hanger Adjustments: Adjust hangers to distribute loads equally on attachments and to achieve indicated slope of pipe.

B. Trim excess length of continuous-thread hanger and support rods to 1-1/2 inches (40 mm).

3.5 PAINTING

A. Touchup: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.
   1. Apply paint by brush or spray to provide a minimum dry film thickness of 2.0 mils (0.05 mm).

B. Touchup: Cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal are specified in Division 9 painting Sections.

C. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.

3.6 HANGER AND SUPPORT SCHEDULE

A. Specific hanger and support requirements are in Sections specifying piping systems and equipment.

B. Use copper-plated pipe hangers and copper attachments for copper piping and tubing.

C. Use padded hangers for piping that is subject to scratching.

D. Horizontal-Piping Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
   1. Adjustable, Steel Clevis Hangers (MSS Type 1): For suspension of noninsulated or insulated, stationary pipes NPS 1/2 to NPS 30 (DN 15 to DN 750).

. E. Hanger-Rod Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
   1. Steel Turnbuckles (MSS Type 13): For adjustment up to 6 inches (150 mm) for heavy loads.

F. Building Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
   1. Steel or Malleable Concrete Inserts (MSS Type 18): For upper attachment to suspend pipe hangers from concrete ceiling.
   2. Top-Beam C-Clamps (MSS Type 19): For use under roof installations with bar-joist construction, to attach to top flange of structural shape.
   3. Side-Beam or Channel Clamps (MSS Type 20): For attaching to bottom flange of beams, channels, or angles.
   4. Center-Beam Clamps (MSS Type 21): For attaching to center of bottom flange of beams.

5. Welded Beam Attachments (MSS Type 22): For attaching to bottom of beams if loads are considerable and rod sizes are large.
6. C-Clamps (MSS Type 23): For structural shapes.
7. Top-Beam Clamps (MSS Type 25): For top of beams if hanger rod is required tangent to flange edge.
8. Side-Beam Clamps (MSS Type 27): For bottom of steel I-beams.
9. Steel-Beam Clamps with Eye Nuts (MSS Type 28): For attaching to bottom of steel I-beams for heavy loads.
10. Linked-Steel Clamps with Eye Nuts (MSS Type 29): For attaching to bottom of steel I-beams for heavy loads, with link extensions.
11. Malleable-Beam Clamps with Extension Pieces (MSS Type 30): For attaching to structural steel.

G. Saddles and Shields: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
   1. Steel-Pipe-Covering Protection Saddles (MSS Type 39): To fill interior voids with insulation that matches adjoining insulation.
   2. Protection Shields (MSS Type 40): Of length recommended in writing by manufacturer to prevent crushing insulation.

H. Use powder-actuated fasteners or mechanical-expansion anchors instead of building attachments where required in concrete construction.

++ END OF SECTION ++

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SECTION 23 05 93

TESTING, ADJUSTING, AND BALANCING FOR HVAC

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:
   1. Balancing Air Systems:
      a. Constant-volume air systems.

1.3 DEFINITIONS

A. AABC: Associated Air Balance Council.

B. NEBB: National Environmental Balancing Bureau.

C. TAB: Testing, adjusting, and balancing.

D. TABB: Testing, Adjusting, and Balancing Bureau.

E. TAB Specialist: An entity engaged to perform TAB Work.

1.4 INFORMATIONAL SUBMITTALS

A. Qualification Data: Within 15 days of Contractor's Notice to Proceed, submit documentation that the TAB contractor and this Project's TAB team members meet the qualifications specified in "Quality Assurance" Article.

B. Contract Documents Examination Report: Within 30 days of Contractor's Notice to Proceed, submit the Contract Documents review report as specified in Part 3.

C. Strategies and Procedures Plan: Within 30 days of Contractor's Notice to Proceed, submit TAB strategies and step-by-step procedures as specified in "Preparation" Article.

D. Certified TAB reports.

E. Sample report forms.

F. Instrument calibration reports, to include the following:
   1. Instrument type and make.
   2. Serial number.
   3. Application.
   4. Dates of use.
   5. Dates of calibration.

1.5 QUALITY ASSURANCE

A. TAB Contractor Qualifications: Engage a TAB entity certified by AABC and NEBB.
   1. TAB Field Supervisor: Employee of the TAB contractor and certified by AABC or NEBB.
   2. TAB Technician: Employee of the TAB contractor and who is certified by AABC or NEBB as a TAB technician.

B. TAB Conference: Meet with Architect on approval of the TAB strategies and procedures plan to develop a mutual understanding of the details. Require the participation of the TAB field supervisor and technicians. Provide seven days' advance notice of scheduled meeting time and location.
   1. Agenda Items:
      a. The Contract Documents examination report.
      b. The TAB plan.
      c. Coordination and cooperation of trades and subcontractors.
      d. Coordination of documentation and communication flow.

C. Certify TAB field data reports and perform the following:
   1. Review field data reports to validate accuracy of data and to prepare certified TAB reports.
   2. Certify that the TAB team complied with the approved TAB plan and the procedures specified and referenced in this Specification.

D. TAB Report Forms: Use standard TAB contractor's forms approved by Architect/Engineer.

E. Instrumentation Type, Quantity, Accuracy, and Calibration: As described in ASHRAE 111, Section 5, "Instrumentation."

F. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 7.2.2 - "Air Balancing."

G. ASHRAE/IESNA Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6.7.2.3 - "System Balancing."

1.6 PROJECT CONDITIONS

A. Full Owner Occupancy: Owner will occupy the site and existing building during entire TAB period. Cooperate with Owner during TAB operations to minimize conflicts with Owner's operations.

B. Partial Owner Occupancy: Owner may occupy completed areas of building before Substantial Completion. Cooperate with Owner during TAB operations to minimize conflicts with Owner's operations.

1.7 COORDINATION

A. Notice: Provide seven days' advance notice for each test. Include scheduled test dates and times.

B. Perform TAB after leakage and pressure tests on air distribution systems have been satisfactorily completed.

PART 2 – PRODUCTS (NOT USED)

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine the Contract Documents to become familiar with Project requirements and to discover conditions in systems' designs that may preclude proper TAB of systems and equipment.

B. Examine systems for installed balancing devices, such as test ports, gage cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers. Verify that locations of these balancing devices are accessible.

C. Examine the approved submittals for HVAC systems and equipment.

D. Examine design data including HVAC system descriptions, statements of design assumptions for environmental conditions and systems' output, and statements of philosophies and assumptions about HVAC system and equipment controls.

E. Examine ceiling plenums and underfloor air plenums used for supply, return, or relief air to verify that they meet the leakage class of connected ducts as specified in Division 23 are properly separated from adjacent areas. Verify that penetrations in plenum walls are sealed and fire-stopped if required.

F. Examine equipment performance data including fan and pump curves.

1. Relate performance data to Project conditions and requirements, including system effects that can create undesired or unpredicted conditions that cause reduced capacities in all or part of a system.
2. Calculate system-effect factors to reduce performance ratings of HVAC equipment when installed under conditions different from the conditions used to rate equipment performance. To calculate system effects for air systems, use tables and charts found in AMCA 201, "Fans and Systems," or in SMACNA's "HVAC Systems - Duct Design." Compare results with the design data and installed conditions.

G. Examine system and equipment installations and verify that field quality-control testing, cleaning, and adjusting specified in individual Sections have been performed.

H. Examine test reports specified in individual system and equipment Sections.

I. Examine HVAC equipment and filters and verify that bearings are greased, belts are aligned and tight, and equipment with functioning controls is ready for operation.

J. Examine heat-transfer coils for correct piping connections and for clean and straight fins.

K. Examine system pumps to ensure absence of entrained air in the suction piping.

L. Examine operating safety interlocks and controls on HVAC equipment.

M. Report deficiencies discovered before and during performance of TAB procedures. Observe and record system reactions to changes in conditions. Record default set points if different from indicated values.

3.2 PREPARATION

A. Prepare a TAB plan that includes strategies and step-by-step procedures.

B. Complete system-readiness checks and prepare reports. Verify the following:
1. Permanent electrical-power wiring is complete.
2. Hydronic systems are filled, clean, and free of air.
3. Automatic temperature-control systems are operational.
4. Equipment and duct access doors are securely closed.
5. Balance, smoke, and fire dampers are open.
6. Isolating and balancing valves are open and control valves are operational.
7. Ceilings are installed in critical areas where air-pattern adjustments are required and access to balancing devices is provided.
8. Windows and doors can be closed so indicated conditions for system operations can be met.

3.3 GENERAL PROCEDURES FOR TESTING AND BALANCING

A. Perform testing and balancing procedures on each system according to the procedures contained in AABC's "National Standards for Total System Balance", NEBB's "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems", SMACNA's "HVAC Systems - Testing, Adjusting, and Balancing" and in this Section.
   1. Comply with requirements in ASHRAE 62.1, Section 7.2.2 - "Air Balancing."

B. Cut insulation, ducts, pipes, and equipment cabinets for installation of test probes to the minimum extent necessary for TAB procedures.
   1. After testing and balancing, patch probe holes in ducts with same material and thickness as used to construct ducts.
   2. After testing and balancing, install test ports and duct access doors that comply with requirements in Division 23.
   3. Install and join new insulation that matches removed materials. Restore insulation, coverings, vapor barrier, and finish according to Division 23.

C. Mark equipment and balancing devices, including damper-control positions, valve position indicators, fan-speed-control levers, and similar controls and devices, with paint or other suitable, permanent identification material to show final settings.

D. Take and report testing and balancing measurements in inch-pound (IP) units.

3.4 GENERAL PROCEDURES FOR BALANCING AIR SYSTEMS

A. Prepare test reports for both fans and outlets. Obtain manufacturer's outlet factors and recommended testing procedures. Crosscheck the summation of required outlet volumes with required fan volumes.

B. Prepare schematic diagrams of systems' "as-built" duct layouts.

C. For variable-air-volume systems, develop a plan to simulate diversity.

D. Determine the best locations in main and branch ducts for accurate duct-airflow measurements.

E. Check airflow patterns from the outdoor-air louvers and dampers and the return- and exhaust-air dampers through the supply-fan discharge and mixing dampers.

F. Locate start-stop and disconnect switches, electrical interlocks, and motor starters.

G. Verify that motor starters are equipped with properly sized thermal protection.

H. Check dampers for proper position to achieve desired airflow path.

I. Check for airflow blockages.

J. Check condensate drains for proper connections and functioning.

K. Check for proper sealing of air-handling-unit components.

L. Verify that air duct system is sealed as specified in Division 23.

3.5 PROCEDURES FOR CONSTANT-VOLUME AIR SYSTEMS

A. Adjust fans to deliver total indicated airflows within the maximum allowable fan speed listed by fan manufacturer.
   1. Measure total airflow.
      a. Where sufficient space in ducts is unavailable for Pitot-tube traverse measurements, measure airflow at terminal outlets and inlets and calculate the total airflow.
   2. Measure fan static pressures as follows to determine actual static pressure:
      a. Measure outlet static pressure as far downstream from the fan as practical and upstream from restrictions in ducts such as elbows and transitions.
      b. Measure static pressure directly at the fan outlet or through the flexible connection.
      c. Measure inlet static pressure of single-inlet fans in the inlet duct as near the fan as possible, upstream from the flexible connection, and downstream from duct restrictions.
      d. Measure inlet static pressure of double-inlet fans through the wall of the plenum that houses the fan.
   3. Measure static pressure across each component that makes up an air-handling unit, rooftop unit, and other air-handling and -treating equipment.
      a. Report the cleanliness status of filters and the time static pressures are measured.
   4. Measure static pressures entering and leaving other devices, such as sound traps, heat-recovery equipment, and air washers, under final balanced conditions.
   5. Review Record Documents to determine variations in design static pressures versus actual static pressures. Calculate actual system-effect factors. Recommend adjustments to accommodate actual conditions.
   6. Obtain approval from Architect for adjustment of fan speed higher or lower than indicated speed. Comply with requirements in Division 15 Sections for air-handling units for adjustment of fans, belts, and pulley sizes to achieve indicated air-handling-unit performance.
   7. Do not make fan-speed adjustments that result in motor overload. Consult equipment manufacturers about fan-speed safety factors. Modulate dampers and measure fan-motor amperage to ensure that no overload will occur. Measure amperage in full-cooling, full-heating, economizer, and any other operating mode to determine the maximum required brake horsepower.

B. Adjust volume dampers for main duct, submain ducts, and major branch ducts to indicated airflows within specified tolerances.
   1. Measure airflow of submain and branch ducts.
      a. Where sufficient space in submain and branch ducts is unavailable for Pitot-tube traverse measurements, measure airflow at terminal outlets and inlets and calculate the total airflow for that zone.
   2. Measure static pressure at a point downstream from the balancing damper, and adjust volume dampers until the proper static pressure is achieved.
   3. Remeasure each submain and branch duct after all have been adjusted. Continue to adjust submain and branch ducts to indicated airflows within specified tolerances.

C. Measure air outlets and inlets without making adjustments.
   1. Measure terminal outlets using a direct-reading hood or outlet manufacturer's written instructions and calculating factors.

D. Adjust air outlets and inlets for each space to indicated airflows within specified tolerances of indicated values. Make adjustments using branch volume dampers rather than extractors and the dampers at air terminals.
   1. Adjust each outlet in same room or space to within specified tolerances of indicated quantities without generating noise levels above the limitations prescribed by the Contract Documents.
   2. Adjust patterns of adjustable outlets for proper distribution without drafts.

3.6 PROCEDURES FOR MOTORS

A. Motors, 1/2 HP and Larger: Test at final balanced conditions and record the following data:
   1. Manufacturer's name, model number, and serial number.
   2. Motor horsepower rating.
   3. Motor rpm.
   4. Efficiency rating.
   5. Nameplate and measured voltage, each phase.
   6. Nameplate and measured amperage, each phase.
   7. Starter thermal-protection-element rating.

B. Motors Driven by Variable-Frequency Controllers: Test for proper operation at speeds varying from minimum to maximum. Test the manual bypass of the controller to prove proper operation. Record observations including name of controller manufacturer, model number, serial number, and nameplate data.

3.7 PROCEDURES FOR CONDENSING UNITS

A. Verify proper rotation of fans.
B. Measure entering- and leaving-air temperatures.

C. Record compressor data.

3.8 PROCEDURES FOR HEAT-TRANSFER COILS

A. Measure, adjust, and record the following data for each electric heating coil:
   1. Nameplate data.
   2. Airflow.
   3. Entering- and leaving-air temperature at full load.
   4. Voltage and amperage input of each phase at full load and at each incremental stage.
   5. Calculated kilowatt at full load.
   6. Fuse or circuit-breaker rating for overload protection.

B. Measure, adjust, and record the following data for each refrigerant coil:
   1. Dry-bulb temperature of entering and leaving air.
   2. Wet-bulb temperature of entering and leaving air.
   3. Airflow.
   4. Air pressure drop.
   5. Refrigerant suction pressure and temperature.

3.9 PROCEDURES FOR TESTING, ADJUSTING, AND BALANCING EXISTING SYSTEMS

A. Perform a preconstruction inspection of existing equipment that is to remain and be reused.
   1. Measure and record the operating speed, airflow, and static pressure of each fan.
   2. Measure motor voltage and amperage. Compare the values to motor nameplate information.
   3. Check the refrigerant charge.
   4. Check the condition of filters.
   5. Check the condition of coils.
   6. Check the operation of the drain pan and condensate-drain trap.
   7. Check bearings and other lubricated parts for proper lubrication.
   8. Report on the operating condition of the equipment and the results of the measurements taken. Report deficiencies.

B. Before performing testing and balancing of existing systems, inspect existing equipment that is to remain and be reused to verify that existing equipment has been cleaned and refurbished. Verify the following:
   1. New filters are installed.
   2. Coils are clean and fins combed.
   3. Drain pans are clean.
   4. Fans are clean.
   5. Bearings and other parts are properly lubricated.
   6. Deficiencies noted in the preconstruction report are corrected.

C. Perform testing and balancing of existing systems to the extent that existing systems are affected by the renovation work.
   1. Compare the indicated airflow of the renovated work to the measured fan airflows, and determine the new fan speed and the face velocity of filters and coils.
   2. Verify that the indicated airflows of the renovated work result in filter and coil face velocities and fan speeds that are within the acceptable limits defined by equipment manufacturer.
   3. If calculations increase or decrease the air flow rates and water flow rates by more than 5 percent, make equipment adjustments to achieve the calculated rates. If increase or decrease is 5 percent or less, equipment adjustments are not required.
   4. Balance each air outlet.

3.10 TOLERANCES

A. Set HVAC system's air flow rates and water flow rates within the following tolerances:
   1. Supply, Return, and Exhaust Fans and Equipment with Fans: Plus or minus 5 percent.
   2. Air Outlets and Inlets: Plus or minus 5 percent.

3.11 REPORTING

A. Initial Construction-Phase Report: Based on examination of the Contract Documents as specified in "Examination" Article, prepare a report on the adequacy of design for systems' balancing devices. Recommend changes and additions to systems' balancing devices to facilitate proper performance measuring and balancing. Recommend changes and additions to HVAC systems and general construction to allow access for performance measuring and balancing devices.

B. Status Reports: Prepare biweekly progress reports to describe completed procedures, procedures in progress, and scheduled procedures. Include a list of deficiencies and problems found in systems being tested and balanced. Prepare a separate report for each system and each building floor for systems serving multiple floors.

3.12 FINAL REPORT

A. General: Prepare a certified written report; tabulate and divide the report into separate sections for tested systems and balanced systems.
   1. Include a certification sheet at the front of the report's binder, signed and sealed by the certified testing and balancing engineer.
   2. Include a list of instruments used for procedures, along with proof of calibration.

B. Final Report Contents: In addition to certified field-report data, include the following:
   1. Pump curves.
   2. Fan curves.
   3. Manufacturers' test data.
   4. Field test reports prepared by system and equipment installers.
   5. Other information relative to equipment performance; do not include Shop Drawings and product data.

C. General Report Data: In addition to form titles and entries, include the following data:
   1. Title page.
   2. Name and address of the TAB contractor.
   3. Project name.
   4. Project location.
   5. Architect's name and address.
   6. Engineer's name and address.
   7. Contractor's name and address.
   8. Report date.
   9. Signature of TAB supervisor who certifies the report.
   10. Table of Contents with the total number of pages defined for each section of the report. Number each page in the report.
   11. Summary of contents including the following:
      a. Indicated versus final performance.
      b. Notable characteristics of systems.
      c. Description of system operation sequence if it varies from the Contract Documents.
   12. Nomenclature sheets for each item of equipment.
   13. Data for terminal units, including manufacturer's name, type, size, and fittings.
   14. Notes to explain why certain final data in the body of reports vary from indicated values.
   15. Test conditions for fans and pump performance forms including the following:
      a. Settings for outdoor-, return-, and exhaust-air dampers.
      b. Conditions of filters.
      c. Cooling coil, wet- and dry-bulb conditions.
      d. Face and bypass damper settings at coils.
      e. Fan drive settings including settings and percentage of maximum pitch diameter.
      f. Inlet vane settings for variable-air-volume systems.
      g. Settings for supply-air, static-pressure controller.
      h. Other system operating conditions that affect performance.

D. System Diagrams: Include schematic layouts of air and hydronic distribution systems. Present each system with single-line diagram and include the following:
   1. Quantities of outdoor, supply, return, and exhaust airflows.

2. Water and steam flow rates.
3. Duct, outlet, and inlet sizes.
4. Pipe and valve sizes and locations.
5. Terminal units.
6. Balancing stations.
7. Position of balancing devices.

E. Air-Handling-Unit Test Reports: For air-handling units with coils, include the following:
   1. Unit Data:
      a. Unit identification.
      b. Location.
      c. Make and type.
      d. Model number and unit size.
      e. Manufacturer's serial number.
      f. Unit arrangement and class.
      g. Discharge arrangement.
      h. Sheave make, size in inches (mm), and bore.
      i. Center-to-center dimensions of sheave, and amount of adjustments in inches (mm).
      j. Number, make, and size of belts.
      k. Number, type, and size of filters.
   2. Motor Data:
      a. Motor make, and frame type and size.
      b. Horsepower and rpm.
      c. Volts, phase, and hertz.
      d. Full-load amperage and service factor.
      e. Sheave make, size in inches (mm), and bore.
      f. Center-to-center dimensions of sheave, and amount of adjustments in inches (mm).
   3. Test Data (Indicated and Actual Values):
      a. Total air flow rate in cfm (L/s).
      b. Total system static pressure in inches wg (Pa).
      c. Fan rpm.
      d. Discharge static pressure in inches wg (Pa).
      e. Filter static-pressure differential in inches wg (Pa).
      f. Preheat-coil static-pressure differential in inches wg (Pa).
      g. Cooling-coil static-pressure differential in inches wg (Pa).
      h. Heating-coil static-pressure differential in inches wg (Pa).
      i. Outdoor airflow in cfm (L/s).
      j. Return airflow in cfm (L/s).
      k. Outdoor-air damper position.
      l. Return-air damper position.
      m. Vortex damper position.

F. Apparatus-Coil Test Reports:
   1. Coil Data:

a. System identification.
b. Location.
c. Coil type.
d. Number of rows.
e. Fin spacing in fins per inch (mm) o.c.
f. Make and model number.
g. Face area in sq. ft. (sq. m).
h. Tube size in NPS (DN).
i. Tube and fin materials.
j. Circuiting arrangement.

2. Test Data (Indicated and Actual Values):
   a. Air flow rate in cfm (L/s).
   b. Average face velocity in fpm (m/s).
   c. Air pressure drop in inches wg (Pa).
   d. Outdoor-air, wet- and dry-bulb temperatures in deg F (deg C).
   e. Return-air, wet- and dry-bulb temperatures in deg F (deg C).
   f. Entering-air, wet- and dry-bulb temperatures in deg F (deg C).
   g. Leaving-air, wet- and dry-bulb temperatures in deg F (deg C).
   h. Water flow rate in gpm (L/s).
   i. Water pressure differential in feet of head or psig (kPa).
   j. Entering-water temperature in deg F (deg C).
   k. Leaving-water temperature in deg F (deg C).
   l. Refrigerant expansion valve and refrigerant types.
   m. Refrigerant suction pressure in psig (kPa).
   n. Refrigerant suction temperature in deg F (deg C).
   o. Inlet steam pressure in psig (kPa).

G. Electric-Coil Test Reports: For electric furnaces, duct coils, and electric coils installed in central-station air-handling units, include the following:
   1. Unit Data:
      a. System identification.
      b. Location.
      c. Coil identification.
      d. Capacity in Btu/h (kW).
      e. Number of stages.
      f. Connected volts, phase, and hertz.
      g. Rated amperage.
      h. Air flow rate in cfm (L/s).
      i. Face area in sq. ft. (sq. m).
      j. Minimum face velocity in fpm (m/s).
   2. Test Data (Indicated and Actual Values):
      a. Heat output in Btu/h (kW).
      b. Air flow rate in cfm (L/s).
      c. Air velocity in fpm (m/s).
      d. Entering-air temperature in deg F (deg C).
      e. Leaving-air temperature in deg F (deg C).
      f. Voltage at each connection.

g. Amperage for each phase.

H. Fan Test Reports: For supply, return, and exhaust fans, include the following:
   1. Fan Data:
      a. System identification.
      b. Location.
      c. Make and type.
      d. Model number and size.
      e. Manufacturer's serial number.
      f. Arrangement and class.
      g. Sheave make, size in inches (mm), and bore.
      h. Center-to-center dimensions of sheave, and amount of adjustments in inches (mm).
   2. Motor Data:
      a. Motor make, and frame type and size.
      b. Horsepower and rpm.
      c. Volts, phase, and hertz.
      d. Full-load amperage and service factor.
      e. Sheave make, size in inches (mm), and bore.
      f. Center-to-center dimensions of sheave, and amount of adjustments in inches (mm).
      g. Number, make, and size of belts.
   3. Test Data (Indicated and Actual Values):
      a. Total airflow rate in cfm (L/s).
      b. Total system static pressure in inches wg (Pa).
      c. Fan rpm.
      d. Discharge static pressure in inches wg (Pa).
      e. Suction static pressure in inches wg (Pa).

I. Round, Flat-Oval, and Rectangular Duct Traverse Reports: Include a diagram with a grid representing the duct cross-section and record the following:
   1. Report Data:
      a. System and air-handling-unit number.
      b. Location and zone.
      c. Traverse air temperature in deg F (deg C).
      d. Duct static pressure in inches wg (Pa).
      e. Duct size in inches (mm).
      f. Duct area in sq. ft. (sq. m).
      g. Indicated air flow rate in cfm (L/s).
      h. Indicated velocity in fpm (m/s).
      i. Actual air flow rate in cfm (L/s).
      j. Actual average velocity in fpm (m/s).
      k. Barometric pressure in psig (Pa).

J. System-Coil Reports: For reheat coils and water coils of terminal units, include the following:
   1. Unit Data:

a. System and air-handling-unit identification.
b. Location and zone.
c. Room or riser served.
d. Coil make and size.
e. Flowmeter type.

2. Test Data (Indicated and Actual Values):
a. Air flow rate in cfm (L/s).
b. Entering-water temperature in deg F (deg C).
c. Leaving-water temperature in deg F (deg C).
d. Water pressure drop in feet of head or psig (kPa).
e. Entering-air temperature in deg F (deg C).
f. Leaving-air temperature in deg F (deg C).

K. Instrument Calibration Reports:
1. Report Data:
a. Instrument type and make.
b. Serial number.
c. Application.
d. Dates of use.
e. Dates of calibration.

3.13 INSPECTIONS

A. Initial Inspection:
1. After testing and balancing are complete, operate each system and randomly check measurements to verify that the system is operating according to the final test and balance readings documented in the final report.
2. Check the following for each system:
a. Measure airflow of at least 5 percent of air outlets.
b. Measure water flow of at least 5 percent of terminals.
c. Measure room temperature at each thermostat/temperature sensor. Compare the reading to the set point.
d. Verify that balancing devices are marked with final balance position.
e. Note deviations from the Contract Documents in the final report.

B. Final Inspection:
1. After initial inspection is complete and documentation by random checks verifies that testing and balancing are complete and accurately documented in the final report, request that a final inspection be made by Architect.
2. The TAB contractor's test and balance engineer shall conduct the inspection in the presence of Architect.
3. Architect shall randomly select measurements, documented in the final report, to be rechecked. Rechecking shall be limited to either 10 percent of the total measurements recorded or the extent of measurements that can be accomplished in a normal 8-hour business day.

4. If rechecks yield measurements that differ from the measurements documented in the final report by more than the tolerances allowed, the measurements shall be noted as "FAILED."
5. If the number of "FAILED" measurements is greater than 10 percent of the total measurements checked during the final inspection, the testing and balancing shall be considered incomplete and shall be rejected.

C. TAB Work will be considered defective if it does not pass final inspections. If TAB Work fails, proceed as follows:
1. Recheck all measurements and make adjustments. Revise the final report and balancing device settings to include all changes; resubmit the final report and request a second final inspection.
2. If the second final inspection also fails, Owner may contract the services of another TAB contractor to complete TAB Work according to the Contract Documents and deduct the cost of the services from the original TAB contractor's final payment.

D. Prepare test and inspection reports.

3.14 ADDITIONAL TESTS

A. Within 90 days of completing TAB, perform additional TAB to verify that balanced conditions are being maintained throughout and to correct unusual conditions.

B. Seasonal Periods: If initial TAB procedures were not performed during near-peak summer and winter conditions, perform additional TAB during near-peak summer and winter conditions.

+ + END OF SECTION + +

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SECTION 23 07 19

HVAC INSULATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes insulating the following HVAC piping and duct systems:
   1. Condensate drain piping, indoors.
   2. Refrigerant suction indoors and outdoors.
   3. Hot water heating piping, indoors.

1.3 QUALITY ASSURANCE

A. Installer Qualifications: Skilled mechanics who have successfully completed an apprenticeship program or another craft training program certified by the Department of Labor, Bureau of Apprenticeship and Training.

B. Surface-Burning Characteristics: For insulation and related materials, as determined by testing identical products according to ASTM E 84, by a testing and inspecting agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, tapes, and cement material containers, with appropriate markings of applicable testing agency.
   1. Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.
   2. Insulation Installed Outdoors: Flame-spread index of 75 or less, and smoke-developed index of 150 or less.

1.4 DELIVERY, STORAGE, AND HANDLING

A. Packaging: Insulation material containers shall be marked by manufacturer with appropriate ASTM standard designation, type and grade, and maximum use temperature.

1.5 COORDINATION

B. Coordinate sizes and locations of supports, hangers, and insulation shields specified in Division 23 Section "Hangers and Supports for HVAC Piping and Equipment."

PART 2 - PRODUCTS

2.1 INSULATION MATERIALS

A. Products shall not contain asbestos, lead, mercury, or mercury compounds.

B. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.

C. Flexible Elastomeric Insulation: Closed-cell, sponge- or expanded-rubber materials. Comply with ASTM C 534, Type I for tubular materials.
   1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
      a. Aeroflex USA, Inc.; Aerocel.
      b. Armacell LLC; AP Armaflex.
      c. K-Flex USA; Insul-Lock, Insul-Tube, and K-FLEX LS.

D. Mineral-Fiber, Preformed Pipe Insulation:
   1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
      a. Fibrex Insulations Inc.; Coreplus 1200.
      b. Johns Manville; Micro-Lok.
      c. Knauf Insulation; 1000-Degree Pipe Insulation.
      d. Manson Insulation Inc.; Alley-K.
      e. Owens Corning; Fiberglas Pipe Insulation.
   2. Type I, 850 deg F Materials: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 547, Type I, Grade A, with factory-applied ASJ. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

2.2 INSULATING CEMENTS

A. Mineral-Fiber Insulating Cement: Comply with ASTM C 195.
   1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
      a. Ramco Insulation, Inc.; Super-Stik.

2.2 ADHESIVES

A. Materials shall be compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated unless otherwise indicated.

B. Flexible Elastomeric and Polyolefin Adhesive: Comply with MIL-A-24179A, Type II, Class I.
   1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
      a. Aeroflex USA, Inc.; Aeroseal.
      b. Armacell LLC; Armaflex 520 Adhesive.
      c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 85-75.
      d. K-Flex USA; R-373 Contact Adhesive.
   2. For indoor applications, use adhesive that has a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
   3. Use adhesive that complies with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers," including 2004 Addenda.

C. Mineral-Fiber Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.
   1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
      a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-127.
      b. Eagle Bridges - Marathon Industries; 225.
      c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 85-60/85-70.
      d. Mon-Eco Industries, Inc.; 22-25.
   2. For indoor applications, use adhesive that has a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
   3. Use adhesive that complies with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers," including 2004 Addenda.

D. ASJ Adhesive, and FSK and PVDC Jacket Adhesive: Comply with MIL-A-3316C, Class 2, Grade A for bonding insulation jacket lap seams and joints.
   1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
      a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-82.
      b. Eagle Bridges - Marathon Industries; 225.

c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 85-50.
d. Mon-Eco Industries, Inc.; 22-25.

2. For indoor applications, use adhesive that has a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
3. Use adhesive that complies with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers," including 2004 Addenda.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of insulation application.
1. Verify that systems to be insulated have been tested and are free of defects.
2. Verify that surfaces to be insulated are clean and dry.
3. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.

B. Mix insulating cements with clean potable water.

3.3 GENERAL INSTALLATION REQUIREMENTS

A. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of piping including fittings, valves, and specialties.

B. Install insulation with longitudinal seams at top and bottom of horizontal runs.

C. Do not weld brackets, clips, or other attachment devices to piping, fittings, and specialties.

D. Keep insulation materials dry during application and finishing.

E. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.

F. Install insulation with least number of joints practical.

G. Apply adhesives at manufacturer's recommended coverage rate and wet and dry film thicknesses.

H. Install insulation with factory-applied jackets as follows:

1. Draw jacket tight and smooth.
2. Cover circumferential joints with 3-inch- wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced 4 inches o.c.
3. Overlap jacket longitudinal seams at least 1-1/2 inches. Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at 2 inches o.c.

I. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal thickness.

J. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.

K. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches beyond damaged areas. Adhere, staple, and seal patches similar to butt joints.

3.4 GENERAL PIPE INSULATION INSTALLATION

A. Requirements in this article generally apply to all insulation materials except where more specific requirements are specified in various pipe insulation material installation articles.

B. Insulation Installation on Fittings, Valves, Strainers, Flanges, and Unions:

1. Install insulation over fittings, valves, strainers, flanges, unions, and other specialties with continuous thermal and vapor-retarder integrity unless otherwise indicated.
2. Insulate pipe elbows using preformed fitting insulation or mitered fittings made from same material and density as adjacent pipe insulation. Each piece shall be butted tightly against adjoining piece and bonded with adhesive. Fill joints, seams, voids, and irregular surfaces with insulating cement finished to a smooth, hard, and uniform contour that is uniform with adjoining pipe insulation.
3. Insulate tee fittings with preformed fitting insulation or sectional pipe insulation of same material and thickness as used for adjacent pipe. Cut sectional pipe insulation to fit. Butt each section closely to the next and hold in place with tie wire. Bond pieces with adhesive.
4. Insulate valves using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe

insulation, or one pipe diameter, whichever is thicker. For valves, insulate up to and including the bonnets, valve stuffing-box studs, bolts, and nuts. Fill joints, seams, and irregular surfaces with insulating cement.

5. Insulate strainers using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. Fill joints, seams, and irregular surfaces with insulating cement. Insulate strainers so strainer basket flange or plug can be easily removed and replaced without damaging the insulation and jacket. Provide a removable reusable insulation cover. For below-ambient services, provide a design that maintains vapor barrier.
6. Insulate flanges and unions using a section of oversized preformed pipe insulation. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker.
7. Cover segmented insulated surfaces with a layer of finishing cement and coat with a mastic. Install vapor-barrier mastic for below-ambient services and a breather mastic for above-ambient services. Reinforce the mastic with fabric-reinforcing mesh. Trowel the mastic to a smooth and well-shaped contour.
8. For services not specified to receive a field-applied jacket except for flexible elastomeric and polyolefin, install fitted PVC cover over elbows, tees, strainers, valves, flanges, and unions. Terminate ends with PVC end caps. Tape PVC covers to adjoining insulation facing using PVC tape.
9. Stencil or label the outside insulation jacket of each union with the word "union." Match size and color of pipe labels.

3.5 INSTALLATION OF FLEXIBLE ELASTOMERIC INSULATION

A. Seal longitudinal seams and end joints with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

B. Insulation Installation on Pipe Fittings and Elbows:
   1. Install mitered sections of pipe insulation.
   2. Secure insulation materials and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

3.2 INSTALLATION OF MINERAL-FIBER INSULATION

A. Insulation Installation on Straight Pipes and Tubes:

   1. Secure each layer of preformed pipe insulation to pipe with wire or bands and tighten bands without deforming insulation materials.
   2. For insulation with factory-applied jackets on above-ambient surfaces, secure laps with outward-clinched staples at 6 inches o.c.

B. Insulation Installation on Pipe Fittings and Elbows:

1. Install preformed sections of same material as straight segments of pipe insulation when available.
2. When preformed insulation elbows and fittings are not available, install mitered sections of pipe insulation, to a thickness equal to adjoining pipe insulation. Secure insulation materials with wire or bands.

C. Insulation Installation on Valves and Pipe Specialties:

1. Install preformed sections of same material as straight segments of pipe insulation when available.
2. When preformed sections are not available, install mitered sections of pipe insulation to valve body.
3. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.

3.6 FINISHES

A. Insulation with ASJ: Paint jacket with paint system identified below and as specified in Division 09 painting Sections.
1. Flat Acrylic Finish: Two finish coats over a primer that is compatible with jacket material and finish coat paint. Add fungicidal agent to render fabric mildew proof.
a. Finish Coat Material: Interior, flat, latex-emulsion size.

B. Flexible Elastomeric Thermal Insulation: After adhesive has fully cured, apply two coats of insulation manufacturer's recommended protective coating.

3.7 INDOOR PIPING INSULATION SCHEDULE

A. Condensate Drain Water below 60 Deg F:
1. All Pipe Sizes: Insulation shall be the following:
a. Flexible Elastomeric: 3/4 inch thick.

B. Refrigerant Suction Piping:
1. All Pipe Sizes: Insulation shall be the following:
a. Flexible Elastomeric: 1 inch thick.

C. Hot Water Space Heating Piping:
1. All Pipe Sizes: Insulation shall be the following:
a. Mineral fiber with all service jacket: 1-1/2" thick.

3.8 OUTDOOR, ABOVEGROUND PIPING INSULATION SCHEDULE

A. Refrigerant Suction Piping:
   1. All Pipe Sizes: Insulation shall be the following:
      a. Flexible Elastomeric: 2 inches thick.

+ + END OF SECTION + +

SECTION 23 09 23.23

PRESSURE MEASUREMENT DEVICES

PART 1 - GENERAL

1.1 WORK INCLUDED

A. The CONTRACTOR shall furnish and install all primary devices, transmitters, and accessory items as shown on the Contract Drawings and as specified herein.

PART 2 - PRODUCTS

2.01 INSTRUMENTS AND ACCESSORY EQUIPMENT

A. Altitude and Pressure Gauges:
   1. All indicating gauges are pipe mounted with male and brass threaded pipe connections. Gauges shall be 4 1/2 inch liquid filled for maximum vibration and corrosion protection. Gauges shall have phosphor bronze Bourdon tubes, white laminated phenol dials. Gauges shall have micrometer adjustment of pointers and black phenol, black cast iron, brass, or aluminum case and ring, original rotary gear design, corrosion resistant, stainless steel movement, blowout protection, and bronze socket with wrench flats. Accuracy shall be within 1/2 of 1 percent of the scale range. They shall be as manufactured by Helicoid Gage Division, "410"; James P. Marsh Corporation, "Master Gauge"; Marshalltown; Ashcroft; U.S. Gauge; or equal.
   2. All gauges shall be piped with provisions for venting pressure to allow calibration (zero) checks. Valves for gauge shutoff and zeroing shall be 1/4 turn ball valves with lever handle, corrosion-resistant.
   3. Liquid filled diaphragm seals shall be installed on all gauges as indicated in the Gauge Schedule in Section 13480 of the Specifications. Diaphragm seals shall be of the continuous duty type, 3 piece construction with 1/4 inch flushing connection, 1/4 inch fill connection, 316 stainless steel lower housing and diaphragm material 1/4 inch gauge connection and 1/2 inch lower connection. Housing bolts shall also be stainless steel. Acceptable models are Marsh 42-01, Helicoid 100H, or equal. Viton diaphragms are required on low range pressure applications (less than 15 psig). Diaphragm seals shall be "permanently" attached to gauges by installation of a lead sealed wire connecting the two. This is to prevent accidental loss of fill fluid. Fill fluid shall be factory installed silicone. All gauges shall be precalibrated, as an assembly with the seal.

B. Pressure Switches

1. Pressure switches shall piston actuated with adjustable differential. Sealed piston devices shall be provided to filter the piston assembly. Range shall be as indicated, or as required for the application. Range adjustment shall be accessible from the outside of the switch housing.
2. Housing and pistons shall be stainless steel. Diaphragms and o-ring seals shall be Viton. Retaining rings shall be Teflon.
3. Switches shall have SPDT contact outputs which shall provide one N.O. and one N.C. contact rated 10A continuous at 120VAC.
4. Switch housings shall be UL listed for NEMA 4, 4X, and 13 applications.
5. Pressure switches shall be manufactured by Square D, Allen Bradley, or equal.

PART 3 - EXECUTION

3.1 INSTALLATION/APPLICATION/ERECTION

A. Instrumentation and accessory equipment shall be installed in accordance with the manufacturer's instructions. The locations of equipment, transmitters, alarms and similar devices shown on the Drawings are approximate only. Exact locations shall be as accepted by the ENGINEER during construction. Obtain in the field all information relevant to the placing of process control work, proceed as directed by the manufacturer and furnish all labor and materials necessary to complete the work in an acceptable manner.

B. The instrumentation installation details on the Drawings indicate the designed installation for the instruments specified. Where specific installation details are not specified or shown on the Drawings, the manufacturer's recommended practice shall be followed.

C. All work shall be executed in full accordance with codes. Should any work be performed contrary to said codes and/or regulations, the CONTRACTOR shall bear full responsibility for such violations and assume all costs arising therefrom. All equipment used in areas designated as hazardous shall be designed for the Class, Division, and Group as required on the Drawings for the locations.

D. Unless specifically shown in the Contract Documents, direct reading or electrical transmitting instrumentation shall not be mounted on process piping. Instrumentation shall be mounted on instrument racks or stands. All instrumentation connections shall be provided with shutoff and drain valves.

E. All piping to and from field instrumentation shall be provided with necessary unions, test tees, couplings, adaptors, and shut-off valves.

F. Field instruments requiring power supplies shall be provided with local electrical shut-offs and fuses as required.

G. Brackets and hangers required for mounting of equipment shall be provided. They shall be installed in a workmanlike manner and not interfere with any other equipment.

H. The system supplier, acting through the CONTRACTOR, shall coordinate the installation, the placing and location of system components, their connections to the process equipment panels, cabinets and devices, subject to the ENGINEER'S acceptance. He shall be responsible to ensure that all field wiring for power and signal circuits are correctly done in accordance with best industry practice and provide for all necessary system grounding to ensure a satisfactory functioning installation. The CONTRACTOR hereunder shall schedule and coordinate his work under this Section with that of the electrical work specified under applicable Sections of Division 26.

++END OF SECTION++

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SECTION 23 21 13

HYDRONIC PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes pipe and fitting materials, joining methods, special-duty valves, and specialties for the following:
   1. Hot-water heating piping.
   2. Condensate drain piping.

1.3 PERFORMANCE REQUIREMENTS

A. Hydronic piping components and installation shall be capable of withstanding the following minimum working pressure and temperature:
   1. Hot-Water Heating Piping: 150 psig at 200 deg F.
   2. Condensate-Drain Piping: 150 deg F.

PART 2 - PRODUCTS

2.1 COPPER TUBE AND FITTINGS

A. Drawn-Temper Copper Tubing: ASTM B 88, Type M.

2.2 STEEL PIPE AND FITTINGS

A. Steel Pipe: ASTM A 53/A 53M, black steel with plain ends; type, grade, and wall thickness as indicated in Part 3 "Piping Applications" Article.

B. Malleable-Iron Threaded Fittings: ASME B16.3, Classes 150 and 300 as indicated in Part 3 "Piping Applications" Article.

2.3 JOINING MATERIALS

A. Solder Filler Metals: ASTM B 32, lead-free alloys. Include water-flushable flux according to ASTM B 813.

PART 3 - EXECUTION

3.1 PIPING APPLICATIONS

A. Hot-water heating piping, aboveground, NPS 2 and smaller, shall be the following:
   1. Schedule 40 steel pipe; Class 150, malleable-iron fittings and threaded joints.

B. Condensate-Drain Piping: Type M, drawn-temper copper tubing, wrought-copper fittings, and soldered joints.

3.2 PIPING INSTALLATIONS

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicate piping locations and arrangements if such were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.

B. Install piping in concealed locations, unless otherwise indicated and except in equipment rooms and service areas.

C. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

D. Install piping to permit valve servicing.

E. Install piping free of sags and bends.

F. Install piping to allow application of insulation.

G. Select system components with pressure rating equal to or greater than system operating pressure.

H. Reduce pipe sizes using eccentric reducer fitting installed with level side up.

I. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Division 23 Section "Escutcheons for HVAC Piping."

3.3 HANGERS AND SUPPORTS

A. Hanger, support, and anchor devices are specified in Division 23 Section "Hangers and Supports for HVAC Piping and Equipment." Comply with the following requirements for maximum spacing of supports.

B. Install the following pipe attachments:

1. Adjustable steel clevis hangers for individual horizontal piping less than 20 feet long.
2. Provide copper-clad hangers and supports for hangers and supports in direct contact with copper pipe.

C. Install hangers for steel piping with the following maximum spacing and minimum rod sizes:

1. NPS 3/4: Maximum span, 7 feet; minimum rod size, 1/4 inch.
2. NPS 1: Maximum span, 7 feet; minimum rod size, 1/4 inch.
3. NPS 1-1/2: Maximum span, 9 feet; minimum rod size, 3/8 inch.
4. NPS 2: Maximum span, 10 feet; minimum rod size, 3/8 inch.

D. Install hangers for drawn-temper copper piping with the following maximum spacing and minimum rod sizes:
1. NPS 1-1/2: Maximum span, 8 feet; minimum rod size, 3/8 inch.

3.4 PIPE JOINT CONSTRUCTION

A. Join pipe and fittings according to the following requirements and Division 23 Sections specifying piping systems.

B. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.

C. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.

D. Soldered Joints: Apply ASTM B 813, water-flushable flux, unless otherwise indicated, to tube end. Construct joints according to ASTM B 828 or CDA's "Copper Tube Handbook," using lead-free solder alloy complying with ASTM B 32.

E. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:

1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.

2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

3.5 FIELD QUALITY CONTROL

A. Prepare hydronic piping according to ASME B31.9 and as follows:

1. Leave joints, including welds, uninsulated and exposed for examination during test.
2. Flush hydronic piping systems with clean water; then remove and clean or replace strainer screens.
3. Isolate equipment from piping. If a valve is used to isolate equipment, its closure shall be capable of sealing against test pressure without damage to valve. Install blinds in flanged joints to isolate equipment.
4. Install safety valve, set at a pressure no more than one-third higher than test pressure, to protect against damage by expanding liquid or other source of overpressure during test.

B. Perform the following tests on hydronic piping:

1. Use ambient temperature water as a testing medium unless there is risk of damage due to freezing. Another liquid that is safe for workers and compatible with piping may be used.
2. While filling system, use vents installed at high points of system to release air. Use drains installed at low points for complete draining of test liquid.
3. Subject piping system to hydrostatic test pressure that is not less than 1.5 times the system's working pressure. Test pressure shall not exceed maximum pressure for any vessel, pump, valve, or other component in system under test. Verify that stress due to pressure at bottom of vertical runs does not exceed 90 percent of specified minimum yield strength or 1.7 times "SE" value in Appendix A in ASME B31.9, "Building Services Piping."
4. After hydrostatic test pressure has been applied for at least 10 minutes, examine piping, joints, and connections for leakage. Eliminate leaks by tightening, repairing, or replacing components, and repeat hydrostatic test until there are no leaks.
5. Prepare written report of testing.

C. Perform the following before operating the system:

1. Open manual valves fully.
2. Set temperature controls so all coils are calling for full flow.

++END OF SECTION++

SECTION 23 23 00

REFRIGERANT PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes refrigerant piping used for air-conditioning applications.

1.3 PERFORMANCE REQUIREMENTS

A. Line Test Pressure for Refrigerant R-410A:
   1. Suction Lines for Air-Conditioning Applications: 300 psig (2068 kPa).
   2. Liquid Lines: 535 psig (3689 kPa).

1.4 ACTION SUBMITTALS

A. Product Data: For each type of valve and refrigerant piping specialty indicated. Include pressure drop, based on manufacturer's test data, for the following:
   1. Thermostatic expansion valves.
   2. Solenoid valves.
   3. Filter dryers.

1.5 INFORMATIONAL SUBMITTALS

A. Welding certificates.

B. Field quality-control test reports.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For refrigerant valves and piping specialties to include in maintenance manuals.

1.7 QUALITY ASSURANCE

A. Welding: Qualify procedures and personnel according to ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."

B. Comply with ASME B31.5, "Refrigeration Piping and Heat Transfer Components."

1.8 PRODUCT STORAGE AND HANDLING

A. Store piping in a clean and protected area with end caps in place to ensure that piping interior and exterior are clean when installed.

1.9 COORDINATION

A. Coordinate size and location of roof curbs, equipment supports, and roof penetrations.

PART 2 - PRODUCTS

2.1 COPPER TUBE AND FITTINGS

A. Copper Tube: ASTM B 280, Type ACR.
B. Wrought-Copper Fittings: ASME B16.22.
C. Wrought-Copper Unions: ASME B16.22.
D. Brazing Filler Metals: AWS A5.8.
E. Flexible Connectors:
   1. Body: Tin-bronze bellows with woven, flexible, tinned-bronze-wire-reinforced protective jacket.
   2. End Connections: Socket ends.
   3. Offset Performance: Capable of minimum 3/4-inch (20-mm) misalignment in minimum 7-inch- (180-mm-) long assembly.
   4. Pressure Rating: Factory test at minimum 500 psig (3450 kPa).
   5. Maximum Operating Temperature: 250 deg F (121 deg C).

2.2 VALVES AND SPECIALTIES

A. Diaphragm Packless Valves:
   1. Body and Bonnet: Forged brass or cast bronze; globe design with straight-through or angle pattern.
   2. Diaphragm: Phosphor bronze and stainless steel with stainless-steel spring.
   3. Operator: Rising stem and hand wheel.
   4. Seat: Nylon.
   5. End Connections: Socket, union, or flanged.
   6. Working Pressure Rating: 500 psig (3450 kPa).
   7. Maximum Operating Temperature: 275 deg F (135 deg C).

B. Solenoid Valves: Comply with ARI 760 and UL 429; listed and labeled by an NRTL.
   1. Body and Bonnet: Plated steel.
   2. Solenoid Tube, Plunger, Closing Spring, and Seat Orifice: Stainless steel.
   3. Seat: Polytetrafluoroethylene.
   4. End Connections: Threaded.
   5. Electrical: Molded, watertight coil in NEMA 250 enclosure of type required by location with 1/2-inch (16-GRC) conduit adapter, and [24] [115] [208]-V ac coil.
   6. Working Pressure Rating: 400 psig (2760 kPa).
   7. Maximum Operating Temperature: 240 deg F (116 deg C).
   8. Manual operator.

C. Thermostatic Expansion Valves: Comply with ARI 750.
   1. Body, Bonnet, and Seal Cap: Forged brass or steel.
   2. Diaphragm, Piston, Closing Spring, and Seat Insert: Stainless steel.
   3. Packing and Gaskets: Non-asbestos.
   4. Capillary and Bulb: Copper tubing filled with refrigerant charge.
   5. Suction Temperature: 40 deg F (4.4 deg C).
   6. Superheat: Adjustable.
   7. Reverse-flow option (for heat-pump applications).
   8. End Connections: Socket, flare, or threaded union.
   9. Working Pressure Rating: 700 psig (4820 kPa).

D. Moisture/Liquid Indicators:
   1. Body: Forged brass.
   2. Window: Replaceable, clear, fused glass window with indicating element protected by filter screen.
   3. Indicator: Color coded to show moisture content in ppm.
   4. Minimum Moisture Indicator Sensitivity: Indicate moisture above 60 ppm.
   5. End Connections: Socket or flare.
   6. Working Pressure Rating: 500 psig (3450 kPa).
   7. Maximum Operating Temperature: 240 deg F (116 deg C).

E. Replaceable-Core Filter Dryers: Comply with ARI 730.
   1. Body and Cover: Painted-steel shell with ductile-iron cover, stainless-steel screws, and neoprene gaskets.
   2. Filter Media: 10 micron, pleated with integral end rings; stainless-steel support.
   3. Desiccant Media: Activated alumina.
   4. End Connections: Socket.
   5. Access Ports: NPS 1/4 (DN 8) connections at entering and leaving sides for pressure differential measurement.
   6. Maximum Pressure Loss: 2 psig (14 kPa).
   7. Working Pressure Rating: 500 psig (3450 kPa).
   8. Maximum Operating Temperature: 240 deg F (116 deg C).

2.3 REFRIGERANTS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   1. Atofina Chemicals, Inc.
   2. DuPont Company; Fluorochemicals Div.
   3. Honeywell, Inc.; Genetron Refrigerants.
   4. INEOS Fluor Americas LLC.

B. ASHRAE 34, R-410A: Pentafluoroethane/Difluoromethane.

PART 3 - EXECUTION

3.1 PIPING APPLICATIONS FOR REFRIGERANT R-410A

A. Suction Lines and Liquid lines NPS 1-1/2 (DN 40) and Smaller for Conventional Air-Conditioning Applications: Copper, Type ACR, annealed-temper tubing and wrought-copper fittings with brazed joints.

3.2 VALVE AND SPECIALTY APPLICATIONS

A. Install diaphragm packless valves in suction and discharge lines of compressor.

B. Except as otherwise indicated, install diaphragm packless valves on inlet and outlet side of filter dryers.

C. Install solenoid valves upstream from each expansion valve. Install solenoid valves in horizontal lines with coil at top.

D. Install thermostatic expansion valves as close as possible to distributors on evaporators.
   1. Install valve so diaphragm case is warmer than bulb.
   2. Secure bulb to clean, straight, horizontal section of suction line using two bulb straps. Do not mount bulb in a trap or at bottom of the line.
   3. If external equalizer lines are required, make connection where it will reflect suction-line pressure at bulb location.

E. Install moisture/liquid indicators in liquid line at the inlet of the thermostatic expansion valve or at the inlet of the evaporator coil capillary tube.

F. Install filter dryers in liquid line between compressor and thermostatic expansion valve.

G. Install flexible connectors at compressors.

3.3 PIPING INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems; indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Shop Drawings.

B. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

C. Install piping adjacent to machines to allow service and maintenance.

D. Install piping free of sags and bends.

E. Install fittings for changes in direction and branch connections.

F. Select system components with pressure rating equal to or greater than system operating pressure.

G. Install piping as short and direct as possible, with a minimum number of joints, elbows, and fittings.

H. Arrange piping to allow inspection and service of refrigeration equipment. Install valves and specialties in accessible locations to allow for service and inspection.

I. Slope refrigerant piping as follows:
   1. Install horizontal suction lines with a uniform slope downward to compressor.
   2. Install traps and double risers to entrain oil in vertical runs.
   3. Liquid lines may be installed level.

J. When brazing, remove solenoid-valve coils and sight glasses; also remove valve stems, seats, and packing, and accessible internal parts of refrigerant specialties. Do not apply heat near expansion-valve bulb.

K. Install piping with adequate clearance between pipe and adjacent walls and hangers or between pipes for insulation installation.

L. Install sleeves for piping penetrations of walls, ceilings, and floors.

M. Install escutcheons for piping penetrations of walls, ceilings, and floors.

3.4 PIPE JOINT CONSTRUCTION

A. Ream ends of pipes and tubes and remove burrs.

B. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.

C. Fill pipe and fittings with an inert gas (nitrogen or carbon dioxide), during brazing or welding, to prevent scale formation.

D. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," Chapter "Pipe and Tube."
   1. Use Type BcuP, copper-phosphorus alloy for joining copper socket fittings with copper pipe.
   2. Use Type BAg, cadmium-free silver alloy for joining copper with bronze or steel.

E. Threaded Joints: Thread steel pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:
   1. Apply appropriate tape or thread compound to external pipe threads unless dry-seal threading is specified.
   2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

F. Welded Joints: Construct joints according to AWS D10.12/D10.12M.

3.5 HANGERS AND SUPPORTS

A. Hanger, support, and anchor products are specified in Section 23 05 29, Hangers and Supports for HVAC Piping and Equipment.

B. Install the following pipe attachments:
   1. Adjustable steel clevis hangers for individual horizontal runs less than 20 feet (6 m) long.
   2. Copper-clad hangers and supports for hangers and supports in direct contact with copper pipe.

C. Install hangers for copper tubing with the following maximum spacing and minimum rod sizes:
   1. NPS 1/2 (DN 15): Maximum span, 60 inches (1500 mm); minimum rod size, 1/4 inch (6.4 mm).
   2. NPS 5/8 (DN 18): Maximum span, 60 inches (1500 mm); minimum rod size, 1/4 inch (6.4 mm).

3. NPS 1 (DN 25): Maximum span, 72 inches (1800 mm); minimum rod size, 1/4 inch (6.4 mm).
4. NPS 1-1/4 (DN 32): Maximum span, 96 inches (2400 mm); minimum rod size, 3/8 inch (9.5 mm).

3.6 FIELD QUALITY CONTROL

A. Perform tests and inspections and prepare test reports.

B. Tests and Inspections:
1. Comply with ASME B31.5, Chapter VI.
2. Test refrigerant piping, specialties, and receivers. Isolate compressor, condenser, evaporator, and safety devices from test pressure if they are not rated above the test pressure.
3. Test high- and low-pressure side piping of each system separately at not less than the pressures indicated in Part 1 "Performance Requirements" Article.
   a. Fill system with nitrogen to the required test pressure.
   b. System shall maintain test pressure at the manifold gage throughout duration of test.
   c. Test joints and fittings with electronic leak detector or by brushing a small amount of soap and glycerin solution over joints.
   d. Remake leaking joints using new materials, and retest until satisfactory results are achieved.

3.7 SYSTEM CHARGING

A. Charge system using the following procedures:
1. Install core in filter dryers after leak test but before evacuation.
2. Evacuate entire refrigerant system with a vacuum pump to 500 micrometers (67 Pa). If vacuum holds for 12 hours, system is ready for charging.
3. Break vacuum with refrigerant gas, allowing pressure to build up to 2 psig (14 kPa).
4. Charge system with a new filter-dryer core in charging line.

3.8 ADJUSTING

A. Adjust high- and low-pressure switch settings to avoid short cycling in response to fluctuating suction pressure.

B. Adjust set-point temperature of air-conditioning to the system design temperature.

C. Perform the following adjustments before operating the refrigeration system, according to manufacturer's written instructions:
1. Open shutoff valves in condenser water circuit.
2. Verify that compressor oil level is correct.
3. Open compressor suction and discharge valves.

4. Open refrigerant valves except bypass valves that are used for other purposes.
5. Check open compressor-motor alignment and verify lubrication for motors and bearings.

D. Replace core of replaceable filter dryer after system has been adjusted and after design flow rates and pressures are established.

+ + END OF SECTION + +

SECTION 23 35 23

POWER VENTILATORS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:
   1. Propeller fans.

1.3 PERFORMANCE REQUIREMENTS

A. Project Altitude: Base fan-performance ratings on actual Project site elevations.

B. Operating Limits: Classify according to AMCA 99.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, and furnished specialties and accessories. Also include the following:
   1. Certified fan performance curves with system operating conditions indicated.
   2. Certified fan sound-power ratings.
   3. Motor ratings and electrical characteristics, plus motor and electrical accessories.
   4. Material thickness and finishes, including color charts.
   5. Dampers, including housings, linkages, and operators.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For power ventilators to include in emergency, operation, and maintenance manuals.

1.6 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1.7 QUALITY ASSURANCE

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

B. AMCA Compliance: Fans shall have AMCA-Certified performance ratings and shall bear the AMCA-Certified Ratings Seal.

1.8 COORDINATION

A. Coordinate size and location of structural-steel support members.

PART 2 - PRODUCTS

2.1 PROPELLER FANS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Chicago Blower Corporation.
   2. Cincinnati Fan.
   3. Greenheck.
   4. Hartzell Fan Incorporated.
   5. Howden Buffalo Inc.
   6. JencoFan.
   7. Loren Cook Company.
   8. PennBarry.

B. Housing: Galvanized-steel sheet with flanged edges and integral orifice ring with baked-enamel finish coat applied after assembly.

C. Steel Fan Wheels: Formed-steel blades riveted to heavy-gage steel spider bolted to cast-iron hub.

D. Fan Drive:
   1. Resiliently mounted to housing.
   2. Statically and dynamically balanced.
   3. Selected for continuous operation at maximum rated fan speed and motor horsepower, with final alignment and belt adjustment made after installation.
   4. Extend grease fitting to accessible location outside of unit.
   5. Service Factor Based on Fan Motor Size: 1.4.
   6. Fan Shaft: Turned, ground, and polished steel; keyed to wheel hub.
   7. Shaft Bearings: Permanently lubricated, permanently sealed, self-aligning ball bearings.
      a. Ball-Bearing Rating Life: ABMA 9, L10 of 100,000 hours.
   8. Pulleys: Cast iron with split, tapered bushing; dynamically balanced at factory.

9. Motor Pulleys: Adjustable pitch for use with motors through 5 hp; fixed pitch for use with larger motors. Select pulley so pitch adjustment is at the middle of adjustment range at fan design conditions.
10. Belts: Oil resistant, nonsparking, and nonstatic; matched sets for multiple belt drives.
11. Belt Guards: Fabricate of steel for motors mounted on outside of fan cabinet.

E. Accessories:
1. Gravity Shutters: Aluminum blades in aluminum frame; interlocked blades with nylon bearings.
2. Motor-Side Back Guard: Galvanized steel, complying with OSHA specifications, removable for maintenance.
3. Wall Sleeve: Galvanized steel to match fan and accessory size.
4. Disconnect Switch: Nonfusible type, with thermal-overload protection mounted inside fan housing, factory wired through an internal aluminum conduit.

F. Capacities and Characteristics: See schedule.

2.5 MOTORS

A. Comply with NEMA, MG1 designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Division 23, Section 23 05 13, Common Motor Requirements for HVAC Equipment.
1. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
2. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in Division 26 Sections.

B. Enclosure Type: Totally enclosed, fan cooled.

2.6 SOURCE QUALITY CONTROL

A. Certify sound-power level ratings according to AMCA 301, "Methods for Calculating Fan Sound Ratings from Laboratory Test Data." Factory test fans according to AMCA 300, "Reverberant Room Method for Sound Testing of Fans." Label fans with the AMCA-Certified Ratings Seal.

B. Certify fan performance ratings, including flow rate, pressure, power, air density, speed of rotation, and efficiency by factory tests according to AMCA 210, "Laboratory Methods of Testing Fans for Aerodynamic Performance Rating." Label fans with the AMCA-Certified Ratings Seal.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install power ventilators level and plumb.

B. Install units with clearances for service and maintenance.

3.2 CONNECTIONS

A. Ground equipment according to Division 26.

B. Connect wiring according to Division 26.

3.3 FIELD QUALITY CONTROL

A. Perform tests and inspections.
   1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

B. Tests and Inspections:
   1. Verify that shipping, blocking, and bracing are removed.
   2. Verify that unit is secure on mountings and supporting devices and that connections to ducts and electrical components are complete. Verify that proper thermal-overload protection is installed in motors, starters, and disconnect switches.
   3. Verify that cleaning and adjusting are complete.
   4. Disconnect fan drive from motor, verify proper motor rotation direction, and verify fan wheel free rotation and smooth bearing operation. Reconnect fan drive system, align and adjust belts, and install belt guards.
   5. Adjust belt tension.
   6. Adjust damper linkages for proper damper operation.
   7. Verify lubrication for bearings and other moving parts.
   8. Remove and replace malfunctioning units and retest as specified above.

C. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

D. Prepare test and inspection reports.

3.4 ADJUSTING

A. Adjust damper linkages for proper damper operation.

B. Adjust belt tension.

C. Comply with requirements in Division 40, Section 23 05 93, Testing, Adjusting, and Balancing for HVAC, for testing, adjusting, and balancing procedures.

D. Replace fan and motor pulleys as required to achieve design airflow.

E. Lubricate bearings.

+ + END OF SECTION + +

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SECTION 23 40 00

LOUVERS AND VENTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:
   1. Adjustable, extruded-aluminum louvers.

B. Related Sections:
   1. Division 26 Sections for electrical power connections for motor-operated adjustable louvers.

1.3 DEFINITIONS

A. Louver Terminology: Definitions of terms for metal louvers contained in AMCA 501 apply to this Section unless otherwise defined in this Section or in referenced standards.

B. Horizontal Louver: Louver with horizontal blades; i.e., the axes of the blades are horizontal.

C. Drainable-Blade Louver: Louver with blades having gutters that collect water and drain it to channels in jambs and mullions, which carry it to bottom of unit and away from opening.

1.4 PERFORMANCE REQUIREMENTS

A. Structural Performance: Louvers shall withstand the effects of gravity loads and the following loads and stresses within limits and under conditions indicated without permanent deformation of louver components, noise or metal fatigue caused by louver blade rattle or flutter, or permanent damage to fasteners and anchors. Wind pressures shall be considered to act normal to the face of the building.
   1. Wind Loads: Determine loads based on a uniform pressure of 20 lbf/sq. ft., acting inward or outward.

B. Louver Performance Ratings: Provide louvers complying with requirements specified, as demonstrated by testing manufacturer's stock units identical to those provided, except for length and width according to AMCA 500-L.

1.5 SUBMITTALS

A. Product Data: For each type of product indicated.
   1. For louvers specified to bear AMCA seal, include printed catalog pages showing specified models with appropriate AMCA Certified Ratings Seals.

B. Product Test Reports: Based on evaluation of comprehensive tests performed according to AMCA 500-L by a qualified testing agency or by manufacturer and witnessed by a qualified testing agency, for each type of louver and showing compliance with performance requirements specified.

1.6 QUALITY ASSURANCE

A. Source Limitations: Obtain louvers and vents from single source from a single manufacturer where indicated to be of same type, design, or factory-applied color finish.

B. Welding: Qualify procedures and personnel according to the following:
   1. AWS D1.2/D1.2M, "Structural Welding Code - Aluminum."

C. SMACNA Standard: Comply with recommendations in SMACNA's "Architectural Sheet Metal Manual" for fabrication, construction details, and installation procedures.

D. UL and NEMA Compliance: Provide motors and related components for motor-operated louvers that are listed and labeled by UL and comply with applicable NEMA standards.

1.7 PROJECT CONDITIONS

A. Field Measurements: Verify actual dimensions of openings by field measurements before fabrication.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Aluminum Extrusions: ASTM B 221, Alloy 6063-T5, T-52, or T6.

B. Aluminum Sheet: ASTM B 209, Alloy 3003 or 5005 with temper as required for forming, or as otherwise recommended by metal producer for required finish.

C. Aluminum Castings: ASTM B 26/B 26M, Alloy 319.

D. Fasteners: Use types and sizes to suit unit installation conditions.
   1. Use hex-head or Phillips pan-head screws for exposed fasteners unless otherwise indicated.
   2. For fastening aluminum, use aluminum or 300 series stainless-steel fasteners.
   3. For color-finished louvers, use fasteners with heads that match color of louvers.

2.2 FABRICATION, GENERAL

A. Assemble louvers in factory to minimize field splicing and assembly. Disassemble units as necessary for shipping and handling limitations. Clearly mark units for reassembly and coordinated installation.

B. Mullions: Louvers shall be constructed without any vertical or horizontal mullions.

C. Maintain equal louver blade spacing to produce uniform appearance.

D. Fabricate frames, including integral sills, to fit in openings of sizes indicated, with allowances made for fabrication and installation tolerances, adjoining material tolerances, and perimeter sealant joints.

   1. Frame Type: Outside flange.

E. Include supports, anchorages, and accessories required for complete assembly.

F. Join frame members to each other and to fixed louver blades with fillet welds, threaded fasteners, or both, as standard with louver manufacturer unless otherwise indicated or size of louver assembly makes bolted connections between frame members necessary.

2.3 ADJUSTABLE, EXTRUDED-ALUMINUM LOUVERS

A. Louver Construction and Operation: Provide adjustable louvers with extruded-aluminum frames and blades not less than 0.080-inch nominal thickness, and with operating mechanisms to suit louver sizes.
   1. Motor operation with 2-position, spring-return application (with power on, motor opens louver; with power off, spring closes louver); 110-V, 60-Hz motor and limit switch.

B. Dual-Blade, Drainable-Blade, Adjustable Louver: Fixed drainable blades and adjustable plain blades combined in single frame.
   1. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
      a. Air Balance Inc.; a Mestek company.
      b. Air Flow Company, Inc.
      c. Airolite Company, LLC (The).

d. All-Lite Architectural Products.
e. American Warming and Ventilating, Inc.; a Mestek company.
f. Arrow United Industries; a division of Mestek, Inc.
g. Cesco Products; a division of Mestek, Inc.
h. Construction Specialties, Inc.
i. Dowco Products Group; Safe-Air of Illinois, Inc.
j. Greenheck Fan Corporation.
k. Industrial Louvers, Inc.
l. Louvers & Dampers, Inc.; a division of Mestek, Inc.
m. NCA Manufacturing, Inc.
n. Metal Form Manufacturing Inc.
o. Reliable Products, Inc.
p. Ruskin Company; Tomkins PLC.
q. United Enertech Corp.
r. Vent Products Company, Inc.

2. Louver Depth: 4 inches, overall.
3. Louver Performance Ratings: See schedule on drawings.
4. AMCA Seal: Mark units with AMCA Certified Ratings Seal.

2.4 LOUVER SCREENS

A. General: Provide screen at each exterior louver.
   1. Screen Location for Adjustable Louvers: Exterior face unless otherwise indicated.
   2. Screening Type: Bird screening except where insect screening is indicated.

B. Secure screen frames to louver frames with machine screws with heads finished to match louver, spaced a maximum of 6 inches from each corner and at 12 inches o.c.

C. Louver Screen Frames: Fabricate with mitered corners to louver sizes indicated.

   1. Metal: Same kind and form of metal as indicated for louver to which screens are attached. Reinforce extruded-aluminum screen frames at corners with clips.
   2. Finish: Same finish as louver frames to which louver screens are attached.
   3. Type: Rewirable frames with a driven spline or insert.

D. Louver Screening for Aluminum Louvers:

   1. Bird Screening: Aluminum, 1/2-inch- square mesh.

2.5 FINISHES, GENERAL

A. Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.

2.6 ALUMINUM FINISHES

A. Two coat 50% KYNAR 500.
   1. Color and Gloss: Classic Bronze GF108.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and openings, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Coordinate setting drawings, diagrams, templates, instructions, and directions for installation of anchorages that are to be embedded in concrete or masonry construction. Coordinate delivery of such items to Project site.

3.3 INSTALLATION

A. Locate and place louvers and vents level, plumb, and at indicated alignment with adjacent work.

B. Use concealed anchorages where possible. Provide brass or lead washers fitted to screws where required to protect metal surfaces and to make a weathertight connection.

C. Form closely fitted joints with exposed connections accurately located and secured.

D. Provide perimeter reveals and openings of uniform width for sealants and joint fillers, as indicated.

E. Repair finishes damaged by cutting, welding, soldering, and grinding. Restore finishes so no evidence remains of corrective work. Return items that cannot be refinished in the field to the factory, make required alterations, and refinish entire unit or provide new units.

3.4 ADJUSTING AND CLEANING

A. Test operation of adjustable louvers and adjust as needed to produce fully functioning units that comply with requirements.

B. Clean exposed surfaces of louvers and vents that are not protected by temporary covering, to remove fingerprints and soil during construction period. Do not let soil accumulate during construction period.

C. Before final inspection, clean exposed surfaces with water and a mild soap or detergent not harmful to finishes. Thoroughly rinse surfaces and dry.

D. Restore louvers and vents damaged during installation and construction so no evidence remains of corrective work. If results of restoration are unsuccessful, as determined by Architect, remove damaged units and replace with new units.
   1. Touch up minor abrasions in finishes with air-dried coating that matches color and gloss of, and is compatible with, factory-applied finish coating.

+ + END OF SECTION + +

SECTION 23 81 25

SPLIT SYSTEM AIR CONDITIONERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes packaged, air-cooled air-conditioning units with refrigerant compressors and controls intended for indoor installations.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, and furnished specialties and accessories.

1.4 INFORMATIONAL SUBMITTALS

A. Warranty: Sample of special warranty.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For self-contained air conditioners to include in emergency, operation, and maintenance manuals.

1.6 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
   1. Filters: Two sets of filters for each unit.

1.7 QUALITY ASSURANCE

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

B. ASHRAE/IESNA Compliance: Applicable requirements in ASHRAE/IESNA 90.1.

1.8 COORDINATION

A. Coordinate sizes and locations of roof curbs, equipment supports and roof penetrations with actual equipment provided.

1.9 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of self-contained air conditioners that fail in materials or workmanship within specified warranty period.
   1. Warranty Period:
      a. For Compressor: Five years from date of Substantial Completion.
      b. For Parts: One year from date of Substantial Completion.
      c. For Labor: One year from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Carrier Corporation; Home Comfort and HVAC Building & Industrial Systems.
   2. Lennox International, Inc.
   3. McQuay International.
   4. Trane Inc.
   5. York; a Johnson Controls company.

2.2 INDOOR UNITS (6 TONS OR MORE)

A. Evaporator-Fan Components:
   1. Chassis: Galvanized steel with flanged edges, removable panels for servicing, and insulation on back of panel. Baked enamel painted finish.
   2. Insulation: Faced, glass-fiber duct liner.
   3. Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins and thermal-expansion valve. Comply with ARI 210/240.
   4. Electric Coil: Helical, nickel-chrome, resistance-wire heating elements; with refractory ceramic support bushings, automatic-reset thermal cutout, built-in magnetic contactors, manual-reset thermal cutout, airflow proving device, and one-time fuses in terminal box for overcurrent protection.

5. Fan: Forward-curved, double-width wheel of galvanized steel; directly connected to motor.
6. Fan Motors:

    a. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements specified in Division 23 Section "Common Motor Requirements for HVAC Equipment."
    b. Multitapped, multispeed with internal thermal protection and permanent lubrication.
    c. Three-phase, permanently lubricated, ball-bearing motors with built-in thermal-overload protection.
7. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1-2004.
8. Filters: 2 inch thick, in fiberboard frames, disposable, 30 percent.
9. Condensate Drain Pans:
    a. Fabricated with one percent slope in at least two planes to collect condensate from cooling coils (including coil piping connections, coil headers, and return bends) and humidifiers, and to direct water toward drain connection.
        1) Length: Extend drain pan downstream from leaving face to comply with ASHRAE 62.1-2004.
        2) Depth: A minimum of 2 inches deep.
    b. Single-wall, non-corroding material.
    c. Drain Connection: Located at lowest point of pan and sized to prevent overflow. Terminate with threaded nipple on one end of pan.

        1) Minimum Connection Size: NPS 1.
    d. Pan-Top Surface Coating: Asphaltic waterproofing compound.

2.3 OUTDOOR UNITS (6 TONS OR MORE)

A. Air-Cooled, Compressor-Condenser Components:

1. Casing: Steel, finished with standard baked enamel color, with removable panels for access to controls, weep holes for water drainage, and mounting holes in base. Provide brass service valves, fittings, and gage ports on exterior of casing.
2. Compressors: Hermetically sealed with crankcase heater and mounted on vibration isolation device. Compressor motors shall have thermal- and current-sensitive overload devices, start capacitor, relay, and contactor.
    a. Compressor Type: Scroll.
    b. Dual circuited unit.
    c. Refrigerant Charge: R-410A.

d. Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins and liquid subcooler. Comply with ARI 210/240. Provide with epoxy-phenolic coating.

3. Fans: Aluminum-propeller type, directly connected to motors.
4. Motors: Permanently lubricated, with integral thermal-overload protection.
5. Low Ambient Kit: Permits operation down to -20 deg F.
6. Mounting Base: Roof equipment rails.

2.2 ACCESSORIES

A. Thermostat: Programmable, multi-stage low voltage with subbase to control compressor and evaporator fan.

B. Automatic-reset timer to prevent rapid cycling of compressor.

C. Refrigerant Line Kits: Soft-annealed copper suction and liquid lines factory cleaned, dried, pressurized, and sealed; factory-insulated suction line with flared fittings at both ends.

D. Equipment rails to support rooftop condensing unit. Thycurb or approved equivalent.

E. Louvered hail guard package.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install units level and plumb.

B. Install evaporator-fan components using manufacturer's standard mounting devices securely fastened to building structure.

C. Install roof-mounted, compressor-condenser components on equipment supports. Anchor units to supports with removable, cadmium-plated fasteners.

D. Install and connect pre-charged refrigerant tubing to component's quick-connect fittings. Install tubing to allow access to unit.

3.2 CONNECTIONS

A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Where installing piping adjacent to equipment, allow space for service and maintenance of equipment.

3.3 FIELD QUALITY CONTROL

A. Tests and Inspections:
   1. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation, and inspect for refrigerant leaks.
   2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
   3. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.

B. Units will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports.

+ + END OF SECTION + +

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SECTION 26 05 05

GENERAL PROVISIONS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 CONTRACTOR'S UNDERSTANDING

A. Contractors bidding work under this Contract shall read and understand Division Zero and Division 1 - General Requirements. If any discrepancies are discovered between the Basic Electrical Materials and Methods and General Requirements, the above mentioned documents shall overrule this section. The Basic Electrical Materials and Methods are intended as a supplement to the above mentioned documents.

B. The Contractor shall bid as outlined in the above mentioned Specifications and shall be governed by any alternates or unit prices called for in the form of proposal.

C. Each Contractor bidding on the work included in these Specifications shall view the building site and carefully examine the contract Drawings and Specifications, so that he/she may fully understand what is to be done, and to document existing conditions.

1.2 SCOPE OF WORK

A. Work included in this section of the Specifications shall include the furnishing of all labor, material, tools, approvals, utility connection fees, excavation, backfill, and other equipment necessary to install the electrical system as shown on the Contract Drawings and as specified herein.

B. It also includes installation and connection of all electrical utilization equipment included in this Contract but furnished by other contractors or suppliers.

C. It is the general intent that all motors shall be furnished with the particular object of equipment it drives, except where a new motor is to be provided for an item of existing equipment (a replacement motor), then it shall be provided under this Division of the Specifications.

D. The Contractor shall furnish and install all conduit, wire, disconnect switches and miscellaneous material to make all electrical connections to all items of utilization equipment or wiring devices except as otherwise specified.

E. Equipment connections shall be made with flexible or rigid conduit as required. Controllers for motors, disconnect switches, and all control, protective and signal

devices for motor circuits, except where such apparatus is furnished mounted and connected integrally with the motor driven equipment, shall be installed, connected and left in operating condition. The number and size of conductors between motors and control or protective apparatus shall be as required to obtain the operation described in these Specifications, and/or by the Contract Documents, and/or as shown in manufacturer furnished, Engineer reviewed Shop Drawings.

F. All devices and items of electrical equipment, including those shown on the Contract Drawings but not specifically mentioned in the Specifications or those mentioned in the Specifications but not shown on the Contract Drawings, are to be furnished under this section of the Specifications. Any such device or item of equipment, if not defined in quality, shall be equal to similar Equipment and/or devices specified herein.

G. All devices and items of equipment mentioned in this section of the Specifications whether electrical or not or whether furnished under this or other Division of the Specifications, shall be installed under this Division of the Specifications, unless specifically indicated otherwise.

H. Where wiring diagrams are not shown on the Contract Drawings, they are to be provided by the supplier of the equipment served and such diagrams shall be adhered to except as herein modified.

I. The following is a list of items that may not be defined clearly on the Contract Drawings or in other parts of these Specifications. The list is meant to be an aid to the Contractor and is not necessarily a complete list of all work to be performed under this Contract:
   1. Connect all motors and accessories furnished by equipment suppliers.
   2. Furnish, install, and connect all motor controls.
   3. Furnish, install, and connect lighting.
   4. Furnish, install, and connect power and signal lines to all instrumentation equipment, and accessories.
   5. Furnish, install, and connect all electrical conduit, duct and cables.
   6. Furnish, install, and connect all telephone boxes, outlets, etc.
   7. Furnish, install, and connect all power distribution equipment.
   8. Remove and properly dispose of all existing wiring and materials not to be reused in the renovated plant, as shown on the Contract Drawings.
   9. Furnish and install communications system cabling, connectors, outlets, etc.

1.3 SHOP DRAWINGS, DESCRIPTIVE LITERATURE, INSTALLATION, OPERATION AND MAINTENANCE INFORMATION

A. Shop Drawings including descriptive literature and/or installation, operation and maintenance instructions shall be submitted in the amount of 8 copies for this Division. All Shop Drawings shall be submitted in loose-leaf three-ring

cardboard reinforced vinyl binders.

B. Shop Drawings shall be submitted on the following materials specified in this Division:
   1. Conduit - all types and sizes, including liquid-tight flexible.
   2. Boxes - all types and sizes.
   3. Coal tar epoxy paint.
   4. Wiring devices.
   5. Device plates.
   6. Supporting Devices/metal framing system (Strut type channel).
   7. Conduit fittings, expansion joints, support hardware.
   8. Motor control equipment - including individually mounted items.
   9. Power distribution equipment - including individually mounted items.
   10. Wire - all types and sizes.
   11. Light fixtures - all types.
   12. Wire markers, signs and labels.
   13. Lightning/surge suppressors.
   14. Motors.
   15. Transformers.
   16. Electrical Studies and Calculations.
   17. Secondary Grounding.
   18. Medium Voltage Equipment.
   19. Communication devices.

C. The Engineer reserves the right to make modifications to motor control and power distribution equipment ratings after Shop Drawing review, if the Shop Drawings are submitted prematurely (prematurely meaning submitted before all utilization equipment has been reviewed and accepted). Cost of modifications shall be the Contractor's responsibility.

1.4 SYMBOLS AND ABBREVIATIONS

A. The symbols and abbreviations generally follow standard electrical and architectural practice, however, exceptions to this shall be as shown on the Contract Drawings.

1.5 COORDINATION WITH OTHER TRADES

A. The Contractor shall coordinate the electrical work with that of other trades to ensure proper final location of all electrical equipment and/or connections. The Contractor shall verify door swings to see that light switches are located properly.

1.6 CODES

A. The minimum standard for all work shall be the latest revision of the Kentucky Building Code (KBC) and the National Electrical Code (NEC). Whenever and

wherever state and/or local laws or ordinances and/or regulations and/or the Engineer's design require a higher standard that the current NEC or KBC, then these laws and/or regulations and/or the design shall be followed.

B. Following is a list of other applicable Standards or Codes:

1.	Kentucky Building Code	KBC
2.	National Electrical Code	NEC
3.	National Electrical Safety Code	NESC
4.	Underwriters Laboratories, Inc.	UL
5.	Factory Mutual System	FM
6.	National Fire Protection Association	NFPA
7.	National Electrical Manufacturers Association	NEMA
8.	Occupational Safety and Health Administration	OSHA
9.	Insulated Cable Engineers Association, Inc.	ICEA
10.	Illuminating Engineering Society of North America	IES
11.	Instrument Society of America	ISA
12.	Institute of Electrical and Electronic Engineers, Inc.	IEEE
13.	Certified Ballast Manufacturers Association	CBM
14.	American National Standards Institute, Inc.	ANSI
15.	Anti-Friction Bearing Manufacturers Association, Inc.	AFBMA
16.	Joint Industry Council	JIC
17.	American Society of Heating, Refrigerating and Air Conditioning Engineers, Inc.	ASHRAE
18.	Federal Communications Commission	FCC
19.	American Society for Testing and Materials	ASTM
20.	American Wood Preservers Association	AWPA
21.	Rural Electrification Association	REA

1.7 INSPECTIONS AND PERMITS

A. Inspection of the electrical system on all construction projects is required. If the local government has appointed a state licensed inspector, the Contractor shall be required to use that person to perform the inspections. If a locally mandated inspector does not exist, the Contractor shall select and hire a state licensed inspector, who has jurisdiction before any work is concealed. The Contractor shall notify the electrical inspector in writing, immediately upon notice to proceed, and a copy of the notice shall be submitted to the Engineer.

B. At the time of completion of the project, there shall be furnished to the Owner a certificate of compliance, from the agency having jurisdiction pursuant to all electrical work performed. The Engineer shall also receive a photostatic copy.

C. All costs incurred by the Contractor to execute the above mentioned requirements shall be paid by the Contractor at no extra cost to the Owner.

D. All permits necessary for the complete electrical system shall be obtained by the

Contractor from the authorities governing such work. For further information, see Division 1.

1.8 STORAGE

A. All work, equipment, and materials shall be protected against dirt, water, or other injury during the period of construction.

B. Sensitive electrical equipment such as light fixtures, motor starters, and controls, delivered to the job site, shall be protected against injury or corrosion due to atmospheric conditions or physical damage by other means. Protection is interpreted to mean that equipment shall be stored under roof, in a structure properly heated in cold weather and ventilated in hot weather. Provision shall be made to control the humidity in the storage area to 50 percent relative. The stored equipment shall be inspected periodically, and if it is found that the protection is inadequate, further protective measures shall be employed. Electrical equipment other than boxes and conduit shall not be installed until the structure is under roof with doors and windows installed.

C. No light fixtures or device plates shall be hung or installed until after painting is completed; however, temporary lighting shall be provided by the Contractor.

1.9 MATERIALS

A. All materials used shall be new and at least meet the minimum standards as established by the NEC and/or National Electrical Manufacturers Association (NEMA). All materials shall be UL listed for the application, where a listing exists. Additional requirements are found in Division 1. All equipment shall meet applicable FCC requirements and restrictions.

B. The material and equipment described herein has been specified according to a particular trade name or make to set quality standards. However, each Contractor has the right to substitute other material and equipment in lieu of that specified, other than those specifically mentioned at matching or for standardization, providing such material and equipment meets all of the requirements of those specified and is accepted, in writing by the Engineer.

C. The reuse of salvaged electrical equipment and/or wiring shall not be permitted unless specified herein or indicated on the Contract Drawings.

D. All salvaged or abandoned electrical materials shall become the property of the Owner. Any removed equipment which the Owner does not want shall be removed from the job site upon completion of the project, unless otherwise noted on the Contract Drawings or specified herein.

1.10 ERRORS, CORRECTIONS, AND/OR OMISSIONS

A. Should a piece of utilization equipment be supplied of a different size or horsepower than shown on the Contract Drawings, the Contractor shall be responsible for installing the proper size wiring, conduit, starters, circuit breakers, etc., for proper operation of that unit and the complete electrical system at no extra cost to the Owner.

B. It is the intent of these Specifications to provide for an electrical system installation complete in every respect, to operate in the manner and under conditions as shown in these Specifications and on the Contract Drawings. The Contractor shall notify the Engineer, in writing, of any omission or error at least 10 days prior to opening of bids. In the event of the Contractor's failure to give such notice, he/she may be required to correct work and/or furnish items omitted without additional cost. Further requirements on this subject may be found in the General Requirements, Division 1.

C. Necessary changes or revisions in electrical work to meet any code or power company requirement shall be made by the Contractor without additional charge to the Owner.

1.11 GUARANTEES AND WARRANTIES

A. The Contractor shall guarantee all work including equipment, materials, and workmanship. This guarantee shall be against all defects of any of the above and shall run for a period of 1 year from the date of acceptance of the work, concurrent with the one year guarantee period designated for the general construction contract under which electrical work is performed. Date of acceptance shall be considered to be the date on which all "punch list" items are completed ("punch list" is defined to be the written listing of work that is incomplete or deficient that must be finished or replaced/repaired before the Contractor receives final payment).

B. Repair and maintenance for the guarantee period is the responsibility of the Contractor and shall include all repairs and maintenance other than that which is considered as routine. (That is oiling, greasing, etc.) The Engineer shall be the judge of what shall be considered as routine maintenance.

C. Where defects (and damage to other Work resulting therefrom) have been corrected or removed and replaced under this Paragraph 1.11, the guarantee with respect to such Work will be extended for an additional period of one year after such correction or removal and replacement has been satisfactory completed and accepted by the Engineer/Owner.

D. Lamps shall bear the manufacturer's warranty.

1.12 TESTING

A. After the wiring system is complete, and at such time as the Engineer may direct, the Contractor shall conduct an operating test for acceptance. The equipment shall be demonstrated to operate in accordance with the requirements of these Specifications and the Contract Drawings. The test shall be performed in the presence of the Engineer or his authorized representative. The Contractor shall furnish all instruments and personnel required for the tests, as well as the necessary electrical power.

B. Before energizing the system, the Contractor shall check all connections and set all relays and instruments for proper operation. He shall obtain all necessary clearances, approvals, and instructions from the serving utility company and/or equipment manufacturers prior to placing power on the equipment.

C. Tests may be requested by the Engineer to determine integrity of insulation on wiring circuits selected by the Engineer at random.

D. Cost of utilities for testing done prior to beneficial occupancy by the Owner shall be borne by the Contractor.

1.13 CLEANUP

A. Cleanup shall be completed as soon as possible after the electrical installation is complete. All light fixtures, outlets, switches, starters, motor control centers, disconnect switches and other electrical equipment shall be free of shipping tags, stickers, etc. All painted equipment shall be left free of scratches or other blemishes, such as splattered or blistered paint, etc. All light fixture diffusers shall be clean and the interior of all motor controls, etc., shall be free of dust, dirt, wire strippings, etc. Surplus material, rubbish and equipment resulting from the work shall be removed from the job site by the Contractor upon completion of the work.

B. During construction, cover all Owner equipment and furnishings subject to mechanical damage or contamination in any way.

1.14 CUTTING AND PATCHING

A. Cutting and patching shall be held to an absolute minimum and such work shall be done only under the direction of the Engineer or Owner. The Contractor shall be responsible for and shall pay for all openings that may be required in the floors or walls, and he shall be responsible for putting said surfaces back in their original condition. Every attempt shall be made to avoid cutting reinforcing steel bars when an opening is required in a reinforced concrete wall or floor slab.

1.15 EXCAVATION AND BACKFILL

A. Excavation
   1. Excavation for conduits shall be of sufficient width to allow for proper jointing, alignment and encasement of the type conduit used. Conduit shall be laid in straight lines between pull boxes and/or structures unless otherwise noted on the Contract Drawings. The cost of solid rock excavation shall be included in the lump sum bid with no extra pay allowed (unclassified).

B. Backfill
   1. Backfill shall be hand placed, loose granular earth for a height of 6 inches above the top of the largest conduit. This material shall be free of rocks over 2 inches in diameter. Above this, large rocks may be included but must be mixed with sufficient earth to fill all voids.

1.16 SLEEVES, CHASES AND OPENINGS

A. Sleeves shall be required at all points where exposed conduits pass through new concrete walls, slabs, or masonry walls. Sleeves that must be installed below grade, or where subject to high water conditions, must be installed watertight.

B. Wiring chases shall be provided where shown on the Contract Drawings. The Contractor shall have the option of installing chases below surface mounted panelboards provided all structural requirements are met.

C. It is the Contractor's responsibility to leave openings to allow installation of the complete, operational electrical system. Openings required but not left shall be cut as outlined under cutting and patching. The Contractor shall coordinate all holes and other openings with necessary diameters for proper firestopping.

1.17 POWER COMPANY COORDINATION

A. The Contractor is responsible for coordinating all activities onsite by the power company.

B. Any special provisions required by the serving electrical utility shall be as outlined on the Contract Drawings or as advised by the utility at the time of construction, and work required by these special provisions shall be executed with no extra cost to the Owner.

1.18 OVERCURRENT PROTECTION

A. Circuit breakers or fused switches shall be the size and type as written herein and shown on the Contract Drawings. Any additional overcurrent protection required to maintain an equipment listing by an authority having jurisdiction shall be installed by the Contractor at no extra cost to the Owner.

B. The Contractor shall submit to the Engineer actual nameplate data from motors shipped to the site, stating motor identification as well as characteristics. Overload relay thermal unit selection tables shall accompany the motor data. The Engineer will select thermal unit sizes from this data for use by the Contractor in ordering proper thermal units.

1.19 TRAINING

A. All manufacturers supplying equipment for this division shall provide the Owner's operations staff with training in the operation and maintenance on the equipment being furnished. The training shall be conducted at the project site by a qualified representative of the manufacturer.

B. The cost of this training shall be included in the bid price.

C. The required training shall consist of both classroom and hands-on situation. Classroom training shall include instruction on how the equipment works, its relationship to all accessories and other related units, detailed review of shop drawings, detailed presentation of written O & M instructions, troubleshooting and record-keeping recommendations. Hands-on-training shall include a review of the manufacturer's O & M instructions, check out of each operator to identifying key elements of the equipment, tear down as appropriate, calibration, adjustment, greasing and oiling points, and operating manipulations of all electrical and mechanical controls.

D. The training shall be scheduled through the Contractor with the Owner. The timing of the training shall closely coincide with startup of the equipment, but no training shall be conducted until the equipment is operational.

E. The minimum number of hours to be provided by manufacturers supplying equipment on this project shall be in accordance with the following table:

Item	Training Hours	
	Classroom	Hands-on
Medium Voltage Motor Controllers	4	4
Medium Voltage Variable Frequency Drives	4	4

F. At least 60 days prior to the training the manufacturer shall submit through the Contractor to the Engineer an outline of the training proposed for the Engineer's review and concurrence.

G. The Owner reserves the right to videotape all training sessions.

1.20 AS BUILT DRAWINGS

A. The Contractor shall maintain 1 set of the Contract Drawings on the job in good condition for examination at all times. The Contractor's qualified representative

shall enter upon these drawings, from day to day, the actual "as-built" record of construction and/or alteration progress. Entries and notes shall be made in a neat and legible manner and these drawings delivered to the Engineer after completion of the construction, for use in preparation of Record Drawings.

1.21 MAINTAINING CONTINUOUS ELECTRICAL SYSTEM AND SERVICE

A. Existing service(s) continuity shall be maintained at all times. In no way shall the installation and/or alteration of the electrical work interfere with or stop the normal operation of the existing facilities, except where prior arrangements have been made. If the Contractor needs to shut down normal building power for any reason or duration, a 2 week notice shall be given to the Owner and the Owner shall approve the outage.

B. Any scheduled power outage shall be performed between midnight and 8 AM. If additional days are required for a power outage, the additional day(s) must be scheduled a minimum of 24 hours after the prior outage. The plant shall not be shut down more than once during a 24 hour period.

C. When additions and taps to existing service(s) require electrical outages of duration in excess of a few minutes, arrangements shall be made in advance for such outages. All outages shall be held to an acceptable minimum with none exceeding 8 hours continuous duration. If necessary, cuts shall be performed on premium time. If performed at night, requiring a general outage, the Contractor shall furnish an auxiliary source of light and power as required. Under no circumstances shall an electrical outage of any duration be initiated until the Owner and Engineer have concurred, and as far as possible in advance.

1.22 GROUNDING AND BONDING

A. All metallic conduit, cabinets, equipment, and service shall be grounded in accordance with the latest issue of the National Electrical Code. All supporting framework and other metal or metal clad equipment or materials which are in contact with electrical conduit, cable and/or enclosures, shall be properly grounded to meet the code requirements.

1.23 RELATED SPECIFICATION DIVISIONS

A. Other Divisions contain Specifications on utilization equipment, equipment accessories, and procedures related to execution of the electrical work, and are included here for the Contractor's information. Bids shall still be based on complete Contract Documents.

1.24 SERVICE ENTRANCE

A. Conductors and terminations for service entrances shall be furnished and installed

by the Contractor. Voltage, phase, and number of wires shall be as shown on the Drawings. Clearances for overhead entrance wires shall be per the Power Company, NEC, and NESC requirements.

B. Any details not shown on the Drawings or written in the Specifications pertaining to the service entrance shall be per power company requirements. It is the Contractor's responsibility to contact the utility prior to bidding and obtain any special requirements or costs they will be imposing. Those costs shall be included in the bid.

1.25 CONTRACTOR LICENSING

A. The Contractor performing the electrical work on this project shall be locally licensed, if required by local law or ordinance. If the Contractor has passed the State test, it may not be necessary to meet local testing requirements. It shall be the Contractor's responsibility to investigate these requirements and comply with same.

1.26 ANCHORING/MOUNTING

A. Electrical conduits and/or equipment shall be rigidly supported. Anchors used shall be metallic expansion type, or if appropriate to prevent spalling concrete, epoxy set type. Plastic or explosive type anchors are prohibited.

B. The Contractor shall ensure that all supports are consistent with the KBC requirements in regard to Seismic Zoning.

1.27 ELECTRICAL COMPONENT MOUNTING HEIGHTS

A. Unless otherwise indicated, mounting height for components shall be as defined herein. In cases of conflicts with architectural or structural aspects, the components may be relocated. If an indicated height conflicts with a code requirement, the code shall govern.

B. Mounting heights are given from finished floor elevation to the centerline of the component, unless otherwise noted.

	Component	**Height**	**Comments**
1.	Wall type light switch	4'-0"	To top of box
2.	Low wall outlet	16"	To bottom
3.	Medium height wall outlet	4'-0"	
4.	Wall type buzzers, horns, etc.	8'-0" Max.	Top 2" below ceiling
5.	Wall type exit signs	8'-0" Max.	Top of sign 2" below ceiling
6.	Push-button or control stations	4'-0"	
7.	Top of panelboards or control panels	6'-6"	Maximum (except for

	Component	Height	Comments
			handicapped areas)
8.	Top of telephone cabinets	6'-6"	Maximum
9.	Top of switch handle on motor control center	6'-6"	Maximum
10.	Top of local motor controller	6'-0"	Maximum
11.	Top of local disconnect switch	6'-0"	Maximum
12.	Wall mount exterior light fixtures	8'-0"	Unless otherwise shown on Contract Drawings

In situations where there appears to be a conflict with Americans with Disabilities Act (ADA) legislation, utilize the ADA requirements herein.

1.28 RECEIPTS

A. Some sections of the Specifications call for equipment, materials, accessories, etc. to be provided and "turned over to the Owner" or like requirements. The Contractor shall obtain a receipt for each item turned over, signed by the Owner or his representative. A copy of this receipt shall be transmitted to the Engineer.

B. When a question arises concerning whether items have been turned over to the Owner, and there is no signed receipt, it may be assumed that the items were not provided.

PART 2 – PRODUCTS (NOT USED)

PART 3 – EXECUTION (NOT USED)

+ + END OF SECTION + +

SECTION 26 05 19

LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

PART 1 - GENERAL

1.1 SCOPE OF WORK

A. All wire and cable shall conform to the latest requirements of the NEC and shall meet all ASTM/UL specifications. Wire and cable shall be new; shall have size, grade of insulation, voltage rating and manufacturer's name permanently marked on the outer covering at regular intervals. Complete descriptive literature shall be submitted to the Engineer for review and acceptance prior to installation.

B. Building wire #12 - #1 shall be applied based on a 60 degree Celsius temperature rise. Building wire larger than #1 may be applied at its 75 degree Celsius temperature rise.

1.2 DELIVERY, STORAGE AND HANDLING

A. Wire and cable shall be suitably protected from weather and damage during storage and handling and shall be in first class condition when installed.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Building Wire (types "THWN" and "THW"-cu.) – "Collyer," "Rome," "American," "Carol," or equal.

B. Flexible Cords and Cables (Types "SO" (600V) "SJO" - 300V) "Collyer," "American," "Carol,"or equal.

C. Instrumentation Cables (Shielded) 600V mx. – "Eaton-Dekoron," "Manhatton," "American," "Belden," "Okonite," or equal.

2.2 MATERIALS

A. General
   1. In general, all conductors shall be 98 percent conductive, annealed copper unless otherwise noted on the Contract Drawings.

   2. Conductors shall be type THWN insulation. Conductor size shall be AWG (American Wire Gauge) Standard. Minimum conductor size shall be AWG number 12 except branch circuits in excess of 75 feet from panel to first

outlet not smaller than no. 10 AWG. Minimum voltage rating shall be 600 volts. Conductors for small power may be solid (i.e. lighting, receptacles), but conductors for control work shall be stranded.

3. Conductors with high temperature rated insulations and special construction shall be used where required in connecting to light fixtures or appliances that have special requirements.

B. Instrument Cables
   1. Refer to Part 3 of this specification section.

PART 3 - EXECUTION

3.1 INSTALLATION/APPLICATION/ERECTION

A. General
   1. Conductors shall be continuous from outlet to outlet and no splices shall be made except accessible in junction or outlet boxes. Wire connectors of insulating material or solderless pressure connectors, properly taped, shall be used for all splices in wiring, wherever possible.
   2. Conductors shall be color coded in accordance with the following schedule:

	480/277V 3 Phase	**208/120V 3 Phase**	**120/240, Single Phase**
Phase A	Brown	Black	Black
Phase B	Orange	Red	Red
Phase C	Yellow	Blue	
Neutral (Grounded)	White or Light Gray	White or Light Gray	White or Light Gray
3-Way Tracers			Blue
Grounding	Green	Green	Green
Remote Energized Conductors (Control)			Orange
Control	Per NFPA 79	Per NFPA 79	

   3. Conductors shall be pulled into raceways in strict accordance with manufacturer's recommendations.
   4. Ample slack conductors shall be allowed at each terminal point, and pull or junction box, to permit installation with ease and without crowding.
   5. All conductors terminating at terminal blocks shall be identified per Specification Section 26 05 53, Identification for Electrical Systems, with numbers and/or letters identical to circuit or control identification.
   6. No conductors shall be drawn into conduits until all work which may cause wire or cable damage is completed. Wire pulling shall be accomplished utilizing machinery and accessories intended for the purpose.

7. All connections and splices shall be made in accordance with conductor manufacturer's recommendations, and as written herein.
8. If the size and number of conductors in a conduit on the Drawings is not shown, then it shall be assumed to be 3 #12, 3/4" C.
9. In general, feeder sizes shown are based on no more than three current carrying conductors in a conduit. Multiple small branch circuit feeders may be combined in a common conduit, provided conductors are derated in accordance with NEC article 310.15.
10. Unless otherwise specifically indicated, neutrals may not be shared.

B. Low Voltage Feeders
1. All feeders are of the secondary type, below 600-volts, unless otherwise noted. The Contractor shall furnish and install all feeders from the distribution center(s) to each of the other structures/subpanels as shown on the Contract Drawings.
2. Wire shall be factory color coded for each phase and neutral, with green used for the grounding conductor. As far as practical, all feeders shall be continuous from origin to panel termination without running splices in intermediate pull boxes.
3. A grounding conductor shall be installed, sized per code, within every conduit containing voltages above 24VAC. Although the metallic conduit system shall be bonded, the metallic conduit systems shall not be the sole source of bonding.

C. Single Shielded Pair Instrument Cable
1. Tinned copper, XLPE insulated stranded conductors, No. 16 AWG minimum, twisted pair with overall shield, stranded tinned No. 18 AWG copper drain wire and overall PVC jacket. Rated for 600 volts minimum and conforming to UL 1581.
2. Manufacturers: Provide products of one of the following:
   a. Belden Company.
   b. Okonite Company.
   c. Dekoron Wire and Cable Company.
   d. Or equal.

D. Multi-paired Shielded Instrument Cable:
1. Tinned copper, XLPE insulated stranded conductors, No. 16 AWG minimum, twisted pairs with shield over each pair, stranded tinned No. 18 AWG copper drain wire, and overall PVC outer jacket. Rated for 600 volts minimum and conforming to UL 1581 or UL 13.
2. Manufacturers: Provide products of one of the following:
   a. Belden Company.
   b. Okonite Company.
   c. Dekoron Wire and Cable Company.
   d. Or equal.

++ END OF SECTION ++

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SECTION 26 05 29

SUPPORTING DEVICES

PART 1 - GENERAL

1.1 SCOPE OF WORK

A. All electric equipment shall be rigidly mounted, and installed using supporting devices as indicated on the Contract Drawings, as required by the work, and described herein.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. "Kindorf," "Unistrut," or equal.

2.2 MATERIALS

A. All mounting brackets and strut used outside shall be aluminum. Fasteners used to mount equipment outside shall be stainless steel.

B. All mounting brackets and strut used inside shall be galvanized or aluminum. If galvanized is used, then the cut ends shall be cold galvanized and painted. Fasteners used inside to mount equipment into concrete shall also be stainless steel. Ungalvanized strut is prohibited.

PART 3 - EXECUTION

3.1 ANCHORING CABINETRY

A. All free standing equipment shall be anchored to its foundation using expansion bolts of the size and number recommended by the equipment manufacturer.

3.2 SEISMIC CONSIDERATIONS

A. Where indicated, seismic restraints shall be provided for electrical equipment.

+ + END OF SECTION + +

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SECTION 26 05 33.13

RIGID CONDUITS

PART 1 - GENERAL

1.1 SCOPE OF WORK

A. This section of the Technical Specifications includes all raceways for accommodation of electrical conductors, communications conductors, sleeves for underground electrical installations, conduit stubs for future installations, fittings and accessories.

B. All raceways shall be marked with the manufacturer's name or trademark as well as type of raceway and size. This marking shall appear at least once every 10 feet and shall be of sufficient durability to withstand the environment involved. All raceways shall be furnished and installed as outlined under Part 3 of this Specification.

C. All raceways and fittings shall be painted to match existing or surrounding surfaces except in mechanical spaces.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Tubular Raceways
   1. Steel, Galvanized, Rigid, Heavy-Wall, Threaded – "Wheatland Tube Co.," "Triangle," "Allied Tube & Conduit Corp.," or equal.
   2. Aluminum, Rigid, Heavy-Wall, Threaded – "VAW," "Alcoa," "Reynolds," or equal.
   3. Plastic (PVC); Type A (Thin Wall); Type 40 (or Schedule 40); Type 80 (or Schedule 80) (Heavy -Wall) – "Robin-Tech," "Carlon," or equal.
   4. Flexible Metal Conduit – "AFC," "Alflex," or equal.
   5. Liquidtight Flexible Metal Conduit – "Carol Cable Co., Inc.," "Superflex," "OZ Gedney," or equal.
   6. Factory Coated Aluminum Conduit - Alumax "ALX-1", or equal.

B. Wireways
   1. "Square-D," "Hoffman," or equal.

C. Raceway Fittings
   1. Conduit fittings – "Crouse-Hinds," "Appleton," "OZ Gedney," or equal.
   2. Non-metallic conduit fittings – "Robin-Tech," "Carlon," "Scepter," or equal.

3. Flexible conduit fittings – "Raco," "T & B," "OZ Gedney," or equal.

2.2 MATERIALS

A. Aluminum Conduit
   1. Aluminum conduit shall be extruded from alloy 6063 and shall be the rigid type, non-toxic, corrosion resistant, and non-staining. It shall be manufactured per UL standards as well as listed/labeled by same.
   2. Fittings, boxes, and accessories used in conjunction with aluminum conduit shall be die cast, copper free type. They shall be resistant to both chemical and galvanic corrosion. All covers shall have neoprene gaskets.
   3. Aluminum conduit proposed for concrete slab or underground applications shall be UL listed for the purpose and factory pre-coated.

B. Rigid Steel Conduit
   1. Rigid steel conduit and fittings shall be of mild steel piping, galvanized inside and out, and shall conform to UL standards. The conduit and fittings hall be listed and labeled by UL as well. The galvanized coating of zinc shall be of uniform thickness applied by the hot-dipped process, and shall be applied also to the threads. It shall be further dipped in a chromic acid bath so as to chemically form a corrosion resistant protective coating of zinc chromate which has a characteristic yellow-green color. Each piece of conduit shall be straight, free from blisters and other defects, cut square, and taper reamed. It shall be delivered with plastic protectors on the threads.

C. Polyvinylchloride (PVC) Conduit
   1. PVC conduit and fittings shall be Schedule 40, 80 heavy wall, or thinwall, as indicated in these Specifications manufactured to conform to UL standards. It shall be listed and labeled by UL. It shall have at least the same temperature rating as the conductor insulation. Expansion joints shall be used as recommended by the manufacturer in published literature. PVC systems shall be 90 degrees Celsius minimum UL rated, have a tensile strength of 7,000 psi @ 73.4 degrees Fahrenheit, flexural strength of 11,000 psi and compressive strength of 8,000 psi.

D. Flexible Conduit
   1. Flexible metallic conduit shall be constructed from flexibly or spirally wound elecro-galvanized steel. Connections shall be by means of galvanized malleable iron squeeze type fittings, or tomic twist-in type in sizes not exceeding 3/4 inch. Liquidtight conduit shall be light gray in color and have sealtight fittings, type UA.

E. Conduit Fittings
   1. Rigid Steel Conduit Fittings
      a. Standard threaded couplings, locknuts, bushings, and elbows made only of steel or malleable iron are acceptable. Integral retractable type IMC couplings are acceptable also.

b. Locknuts: Bonding type with sharp edges for digging into the metal wall of an enclosure.
c. Bushings: Metallic insulating type, consisting of an insulating insert molded or locked into the metallic body of the fitting. Bushings made entirely of metal or nonmetallic material are not permitted.
d. Erickson (union-type) and set screw type couplings: Approved for use in concrete are permitted or use to complete a conduit run where conduit is installed in concrete. Use set screws of case hardened steel with hex head and cup point to firmly seat in conduit wall for positive ground. Tightening of set screws with pliers is prohibited.
e. Sealing fittings: Threaded cast iron type. Use continuous drain type sealing fittings to prevent passage of water vapor. In concealed work, installed fittings in flush steel boxes with blank coverplates having the same finishes as that of other electrical plates in the room.
f. Fittings for PVC coated rigid conduit shall be manufactured by the maker of the conduit.

2. Rigid Aluminum Conduit Fittings
   a. Standard threaded couplings, locknuts, bushings, and elbows: Malleable iron, steel or aluminum alloy materials. Zinc or cadmium plate iron or steel fittings. Aluminum fittings containing more than 0.4 percent copper are prohibited.
   b. Locknuts and bushings: As specified for rigid steel and IMC conduit.
   c. Set screw fittings: Not permitted for use with aluminum conduit.
3. Electrical Metallic Tubing Fittings
   a. Only material of steel or malleable iron is acceptable.
   b. Couplings and connectors: Concrete tight and rain tight, with connectors having insulated throats. Use gland and ring compression type couplings and connectors for conduit sizes 2-inches and smaller. Use set screw type couplings with four set screws each for conduit sizes over 2-inches. Use set screws of case hardened steel with hex head and cup point to firmly seat in wall of conduit for positive grounding.
   c. Indent type connectors or couplings are prohibited.
   d. Die-cast or pressure-cast zinc-alloy fittings or fittings made of "pot metal" are prohibited.
4. Expansion and Deflection Couplings
   a. Accommodate 1.9 cm (0.75 inch) deflection, expansion, or contraction in any direction, and allow 30 degree angular deflections.
   b. Include internal flexible metal braid sized to guarantee conduit ground continuity and fault currents in accordance with UL, and the NEC code tables for ground conductors.
   c. Watertight, seismically qualified, corrosion-resistant, threaded for and compatible with rigid or intermediate metal conduit.
   d. Jacket: Flexible, corrosion-resistant, watertight, moisture and heat resistant molded rubber material and stainless steel jacket clamps.

PART 3 - EXECUTION

3.1 PREPARATION

A. Exterior underground metallic conduits shall be degreased, pretreated, and coated with 2 coats of Carboline 888 epoxy, or equal. Other finishes may be acceptable upon the Engineer's review.

3.2 INSTALLATION

A. Conduit
   1. All conduit shall be installed in a first class workmanship manner. It shall be installed in horizontal and vertical runs in such a manner as to ensure against trouble from the collection of trapped condensation and shall be arranged so as to be devoid of traps wherever possible. Special care shall be used in assuring that exposed conduit runs are parallel or perpendicular to walls, structural members, or intersections of vertical planes and ceilings. No open wiring is allowed.
   2. Fittings or symmetrical bends shall be required wherever right angle turns are made in exposed work. Bends and offsets shall be avoided wherever possible, but where necessary, they shall be made with an approved conduit bending machine. All conduit joints shall be cut square, reamed smooth and drawn up tight, using couplings intended for the purpose.
   3. Conduits shall be securely fastened to all sheet metal outlets, junction and pull boxes with double galvanized locknuts and insulating-grounding bushings as required by the NEC. Conduit crossings in insulating roof fill will require both conduits to be secured to the roof deck, and these crossings can only be made where the insulating fill is a minimum of 3 inches deep. Runs of exposed conduit shall be supported in accordance with the NEC using cast aluminum or malleable iron one hole pipe straps with spacers to provide an air space behind the conduit. Stainless steel minerallac, one piece conduit clamps shall be acceptable where located such that building occupants are not in danger of inadvertent contact, since this type fitting has several sharp edges. In general terms, they may be considered in areas such as on or above ceilings, or high on walls. All conduit in walls and slabs shall be securely braced, capped (wooden plugs are prohibited), and fastened to the forms to prevent dislodgement during vibration and pouring of concrete.
   4. During construction, all conduit work shall be protected to prevent lodgement of dirt, plaster or trash in conduits, fittings or boxes. Conduits which have been plugged shall be entirely freed of accumulations or be replaced. All conduits in floors or below grade shall be swabbed free of debris and moisture before wires are pulled. Crushed or deformed conduit shall not be permitted.
   5. All open conduit work through new walls or slabs shall be run through sleeves that shall be made watertight. These sleeves shall be PVC of suitable diameter to permit the passage of the conduit used.

6. Where GRS conduit penetrates a floor slab the conduit shall be painted with 2 coats of Koppers Bitumastic 300-M or equal to a point 6 inches above the penetration.
7. The final section of conduit connecting each motor or piece of utilization equipment subject to vibration shall be of the flexible type. Type "UA" shall be used in all process areas and in outdoor or wet locations. Flexible conduit to space heaters shall be long enough to allow swivel action.
8. All underground conduits entering a building shall be sealed against water/condensate entering around the conductors. Sealant may be silicone rubber based caulk.
9. In certain situations, conduit expansion joints shall be required to ensure against conduit and/or cable damage due to settling or thermal expansion and contraction. These expansion joints shall be required where required by the manufacturer or the Contract Drawings and shall be installed per manufacturers instructions.
10. Control panels, panelboards, etc., mounted in a building with a basement or pipe gallery below, shall have the conduit opening left in the slab sealed to prevent moisture, dust, etc., from entering the panel. The type of seal to be used shall be silicone elastomer foam, as manufactured by Dow-Corning, Chase-foam as manufactured by Chase Technology Corporation, T & B, or equal.
11. All conduit to be added to an existing structure shall be exposed in unfinished and process areas. Where new devices are shown in existing walls in finished spaces, every attempt shall be made to conceal the conduit, by fishing flexible conduit through walls from ceiling cavities.
12. All conduit work in the finished space of each new structure shall be concealed except for conduits to lighting fixtures in buildings with precast roof slabs, open joist ceilings, or excepted as noted on the Contract Drawings. All conduit work below ground floor level in each structure shall be exposed. Conduits entering from underground into buildings shall be watertight through the wall, both inside and outside.
13. PVC conduit installed underground for low voltage application shall be schedule 40 encased in 4" of concrete. Transition shall be made to PVC coated GRS conduit where exiting concrete to above grade.
14. Aluminum conduit shall not be used underground, in chlorine storage/feed areas, or placed in concete slabs.
15. Conduit stubs, for future use, extended through outside walls shall be capped with threaded pipe caps and coated to prevent corrosion. Stubs shall extend 5 feet beyond the walls from which they are stubbed unless otherwise indicated on the Contract Drawings.
16. All metal raceway systems shall be grounding conductive, solidly bonded throughout and grounded in accordance with NEC requirements and/or as noted on the Contract Drawings. In addition, all raceway systems shall be provided with separate grounding conductors.
17. Minimum conduit size shall be 3/4 inch. The following table shows the minimum burial depth required for all exterior conduit or cable:

Rigid Metal Conduit	24"
Encased Schedule 40 PVC	24"

18. Wire pulling shall be facilitated by the use of a UL approved pulling compound in pulls over 30 feet in length or where there are 2 or more 90 degree bends. Only polypropylene, nylon, or manila pulling ropes will be permitted. Standard industry recognized wire pulling equipment shall be used.
19. All conduits entering and leaving instrument enclosures shall be sealed around the wires with silicone caulk.
20. Areas of use for each type of conduit:

Buildings – Interior	Schedule 40 PVC	Schedule 80 PVC	EMT	GRS	Aluminum
Process Areas (Exposed)				X	X
Non Process Areas (Exposed)				X	X

Exterior Underground	Schedule 40 PVC	Schedule 80 PVC	EMT	GRS	Aluminum
Low Voltage	X	X		X	

Exterior Exposed	Schedule 40 PVC	Schedule 80 PVC	EMT	GRS	Aluminum
Low Voltage				X	X

21. Underground raceways (conduit) shall be concrete encased where they pass over or under obstructions, such as: sidewalks; roadways; piping; etc.
22. All conduit shall have an insulated ground wire pulled to all equipment and receptacles.
23. All raceway runs are shown diagrammatically to outline the general routing of the raceway. The installation shall be made to avoid interference with pipes, ducts, structural members or other equipment. Should structural or other interference prevent the installation of the raceways, or setting of boxes, cabinets, or the electrical equipment, as indicated in the Drawings, deviations must be approved by the Owner, and after approval, shall be made without additional charges and shown on the Record Drawings.
24. Fire Stop: Where conduits, wireways, and other electrical raceways pass through fire partitions, fire walls, smoke partitions, or floors, install a fire stop that provides an effective barrier against the spread of fire, smoke and gases, with rock wool fiber or silicone foam sealant only. Completely fill and seal clearances between raceways and openings with the fire stop material.
25. Assure conduit installation does not encroach into the ceiling height head room, walkways, or doorways.

26. No conduit shall be run exposed across roofs without first obtaining permission from the Engineer.
27. Conduit may be run inside concrete slabs as long as the slab is at least 6-inches thick and conduit will have at least 1 2-inches of cover on both sides.
28. Flexible conduit used in mechanical rooms shall be liquid tight.
29. Runs of flexible conduit above accessible ceilings shall be limited to 10 ft. Runs of exposed flexible conduit shall be limited to 5 ft. All runs of flexible conduit shall be supported in accordance with NEC requirements.
30. Where underground conduits are to be concrete encased, Contractor shall provide #4 rebar equally space for full length of concrete encasement. Rebar shall be parallel to conduit. Provide number of rebar as indicated on project drawings.

+ + END OF SECTION + +

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SECTION 26 05 33.30

WIRE CONNECTIONS AND CONNECTING DEVICES

PART 1 - GENERAL

1.1 SCOPE OF WORK

A. Wire connection and connecting devices shall be as herein specified.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Connectors, Lugs, etc. – "T & B", "Anderson", "Burndy", or equal.

B. Termination and splice connectors – "3M Scotchlok", "Anderson", "T & B", "Burndy", or equal.

2.2 MATERIALS

A. Wire Splicing and Terminations (600 Volts and Below)
   1. Electrical Terminal and Splice Connectors (#22 - #4 AWG)
      a. Terminals and splice connectors from #22 - #4 AWG shall be compression types with barrels to provide maximum conductor contact and tensile strength. Performance, construction, and materials shall be in conformance with UL standards for wire connectors and rated for 600 volts and 105 degrees Celsius.
      b. Connectors shall be manufactured from high conductivity copper and entirely tin plated. Terminal barrels shall be serrated on the inside surface and have a chamfered conductor entry. Terminals shall have funnel entry construction to prevent strand fold-back. All barrels shall be brazed seam or seamless construction.
      c. Spade type terminals shall be sized for the appropriate stud and shall be locking type that snap firmly onto studs with a close fit for maximum retention. Spade type terminals shall be insulated with an insulation suitable for maintaining a high dielectric strength when crimped and be made form nylon, PVC, or equal.
   2. Electrical Lugs and Connectors (#6 AWG - 1000 Kcmil)
      a. Lugs and splice connectors from #6 AWG - 1000 Kcmil shall be compression types with barrels to provide maximum conductor contact and tensile strength. They shall be manufactured from high conductivity copper and entirely tin plated. They shall be crimped with standard industry tooling. The lugs and connectors must have a current carrying capacity equal to the conductors for which they are rated and must also meet all UL requirements. All lugs above 4/0

AWG shall be 2 hole lugs with NEMA spacing. The lugs shall be rated for operation through 35 KV. The lugs shall be of closed end construction to exclude moisture migration into the cable conductor.

3. Twist-on Wire Connectors (#22 AWG - #10 AWG)
   a. All twist-on wire connectors must have a corrosion resistant spring that is free to expand within a steel jacket. The steel jacket must be insulated with a flexible vinyl jacket capable of withstanding 105 degrees Celsius ambient temperatures and of sufficient length to cover wires that are inadvertently overstripped.
   b. Each connector size must be listed by UL for the intended purpose and color coded to assure that the proper size is used on the wire combinations to be spliced. The connectors must be compatible with all common rubber and thermoplastic wire insulations.
4. Solderless/re-usable lugs shall be used only when furnished with equipment such as control panels, furnished by others, where specification of compression type lugs is beyond the Contractor's control. In the event their use is necessary, the Contractor shall be responsible for assuring that they are manufactured to NEMA standards, with proper number and spacing of holes and set screws.

PART 3 - EXECUTION

3.1 INSTALLATION, APPLICATION, & ERECTION

A. Insulation of Splices and Connections
   1. Connections/splices with a smooth even contour shall be insulated with a conformable 7 mil thick vinyl plastic insulating tape which can be applied under all weather conditions and is designed to perform in a continuous temperature environment up to 105 degrees Celsius. The tape shall have excellent resistance to abrasion, moisture, alkalies, acids, corrosion, and varying weather conditions (including sunlight). The tape shall be equal to Scotch 33+ and shall be applied in conformance with manufacturer's recommendations. In addition, it shall be applied in successive half-lapped layers with sufficient tension to reduce its width to 5/8 of its original width. The last inch of the wrap shall not be stretched.
   2. Connections/splices with irregular shapes or sharp edges protruding shall be first wrapped with 30 mil rubber tape to smooth the contour of the joint before being insulated with 33+ insulating tape specified in the previous paragraph. The rubber tape shall be high voltage (69 KV) corona-resistant based on self-fusing ethylene propylene rubber and be capable of operation at 130 degrees Celsius under emergency conditions. The tape must be capable of being applied in either the stretched or unstretched condition without any loss in either physical or electrical properties. The tape must not split, crack, slip, or flag when exposed to various environments. The tape must be compatible with all synthetic cable insulations. The tape must have a dissipation factor of less than 5 percent at 130 degrees Celsius, be

non-vulcanizing, and have a shelf life of a least 5 years. The rubber tape shall be applied in successive, half-lapped wound layers and shall be highly elongated to eliminate voids. Other manufacturer's recommendations on installation shall be adhered to. The rubber tape shall be equal to Scotch 23 or 130C electrical splicing tape.

3. Splices made in wet or damp locations shall be made submersible and watertight with special kits made for the application and compatible with type of cables employed.

B. Connection Make-up

1. Connections of lugs to bus bars, etc., shall be made up with corrosion resistant steel bolts having non-magnetic properties with matching nuts, and shall utilize a Belleville spring washer (stainless steel) to maintain connection integrity. Connections shall be torqued to the proper limits. Prior to bolting up the connection, electrical joint compound shall be brushed on the contact faces of the electrical joint.
2. All motor lead connections shall be made up to match the type of lead furnished on the motor. If the lead is not lugged, then twist-on wire connectors may be used. To prevent possible vibration problems, twist-on connectors shall be taped after installation.
3. All lugged motor lead connections (excluding motors over 200 horse-power) shall be made up using ring tongue compression lugs with proper size stainless steel nuts and bolts. Belleville type spring shall be used to maintain tension on the connections. The connections shall then be insulated using the procedure described for irregular shapes, utilizing rubber tape in conjunction with vinyl electrical tape.
4. At the time of final inspection, the Engineer may request the Contractor to disassemble 3 randomly selected motor lead connections in the Engineer's presence, to assure conformance with these Specifications.
5. The Contractor shall include all necessary tools, materials, and labor in his bid for disassembly of the connections and for remaking them with new insulating materials after inspection.

++ END OF SECTION ++

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SECTION 26 05 33.36

OUTLET BOXES

PART 1 - GENERAL

1.1 SCOPE OF WORK

A. Outlet and junction boxes shall be furnished and installed where indicated on the Contract Drawings, and\or as required by the work in accordance with the NEC.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Boxes – "Queen," "Wiegmann," "Appleton," "Raco," "Bauers," "Crouse-Hinds," "Hoffman," "Robroy Industries," "Cloud Concrete Products," "Spring City," "Carlon," "Sedco," or equal.

2.2 GENERAL

A. All junction and/or pull boxes for dry (non-corrosive) areas shall be of code gauge sheet metal construction, of the inside dimensions as required by code, with covers.

B. Junction and/or pull boxes for wet or damp locations shall be cast metal, rust and corrosion resistant (NEMA 4X), with at least 5-1/2 full threads for each (bossed) conduit opening, and shall be suitable for flush or surface mounting as required with drilled external, cast mounting extensions (bossed to provide at least 1/8" between back of box and mounting surface for drainage). Box covers shall be hinged or cap screw retained as required, of the same material as the box and provided with stainless steel (rustproof) hardware.

C. Junction boxes for out-of-doors use, not mounted in concrete may be sheet metal (NEMA 4X), waterproof, rustproof, rain and sleetproof, with hinged covers and latches and provided means of locking by means of keyed locks, tamper-resistant screws or padlocking as required and with clamping cap-screws top and bottom door edges to provide firm contact with gasketing. All gaskets shall be molded (unbroken) neoprene or butyl rubber.

D. NEMA 4X junction and/or pull boxes may be stainless steel, if called for on the Contract Drawings; or non-metallic or cast aluminum.

E. Underground junction or pull boxes shall be constructed of reinforced concrete cast-in-place or pre-fabricated as detailed on the Contract Drawings.

PART 3 - EXECUTION

3.1 INSTALLATION, APPLICATION, AND ERECTION

A. General
   1. Outlets shall be installed in the locations shown on the Contract Drawings. The Contractor shall study the general building plans in relation to the space surrounding each outlet, in order that his work may fit the other work required by these Specifications. When necessary, the Contractor shall relocate outlets so that when fixtures or other fittings are installed, they will be symmetrically located according to room layout and will not interfere with other work or equipment.
   2. All supports for outlet boxes shall be furnished and installed by the electrical trades.

B. Concealed Work
   1. All outlet boxes shall be standard galvanized steel type at least 12 inches deep, single or gang type of size to accommodate devices shown. Exceptions shall be noted on the Contract Drawings.
   2. Standard deep type outlet boxes (concrete rings with appropriate covers) shall be used in floor slab construction so concealed conduits entering sides of boxes can clear reinforcing rods.
   3. Outlet boxes for concealed telephone and signaling systems shall be the 4-inch square type, unless otherwise noted or required by the telephone company.
   4. Boxes for use in masonry construction shall be 22 inches deep for 4-inch block and 32 inches deep for 6- and 8-inch block. Through wall boxes are prohibited for outlets opposite each other.

C. Exposed Work
   1. Outlet or junction boxes for use with exposed steel conduit shall be cast steel. In dry areas, sheet steel with rounded corners, made for the purpose.
   2. Outlet or junction boxes for use with exposed aluminum conduit shall be copper free, cast aluminum type.
   3. Outlet or junction boxes for use with exposed PVC conduit shall be PVC.

D. Pull Boxes
   1. Pull boxes for exterior underground work are shown on the Contract Drawings and are the minimum number required. Others may be added at the Contractor's option, but no extra pay shall be allowed. Interior pull boxes are not shown but shall be used as needed. Pull box types are as follows:
      a. Exterior – Per detail on the Contract Drawings.

b. Interior – Interior pull boxes in dry areas shall be of code gauge steel of not less than the minimum required by the NEC and shall be provided with hinged covers. In wet areas or pipe galleries, they shall be rated watertight, of stainless steel, cast aluminum, PVC, fiberglass, or equal. Hardware shall be stainless steel.

E. Openings in Electrical Boxes

1. All openings in electrical equipment, enclosures, cabinets, outlet and junction boxes shall be by means of welded bosses, standard knockouts, or shall be sawed, drilled, or punched with tools specially made for the purpose. The use of a cutting torch is prohibited. Unused openings shall be plugged per the NEC.

++ END OF SECTION ++

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SECTION 26 05 36

CABLE TRAYS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SCOPE OF WORK

A. Furnish and install cable tray systems complete, of straight sections, fittings, and accessories as defined in the latest NEMA standards publication VE-1.

B. The general rating of trays shall be as shown on the Contract Drawings.

C. Cable tray provided shall be UL listed as suitable as an equipment grounding conductor.

1.2 RELATED WORK

A. Special requirements for materials and equipment are given in Division 0 and 1.

B. Special sequence or schedule requirements are found in the Summary of Work.

1.3 QUALIFICATIONS

A. These materials shall be furnished by a single manufacturer who is experienced, reputable, and qualified in the manufacture of cable trays. It shall be manufactured by Square D, B-Line, or equal.

1.4 SUBMITTALS

A. Shop drawings and other items needed to establish compliance with the Contract Drawings and these Specifications shall be submitted to the Engineer in accordance with Project General and/or special Conditions. As a minimum, submittals shall include descriptive literature, dimensions, weights, layout drawings, materials of construction, NEMA load class, rung spacing, depth, and shall include accessories/fittings.

1.5 WARRANTY

A. These materials shall be warranted for one year concurrent with the Contractor provided warranty.

PART 2 - PRODUCTS

2.1 MATERIALS AND FINISHES

A. Straight section and fitting side rails and rungs shall be extruded from Aluminum Association Alloy 6063. Fabricated parts shall be made from Alloy 5052.

2.2 TRAY TYPES

A. Ladder

1. Ladder type trays shall consist of two longitudinal members (side rails) with transverse members (rungs) welded to the side rails. Rungs shall be spaced 6 inches on center. Rung spacing in radiused fittings shall be measured at the center of the tray's width. Rungs shall have a minimum cable bearing surface of 7/8" with radiused edges. No portion of the rungs shall protrude below the bottom plane of the side rails.

2.3 TRAY SIZE

A. Trays shall have an overall nominal depth of 5 inches with a minimum usable loading depth of 4 inches.

B. Straight sections side rails shall be I-beam, C rail or Z rails. All straight sections shall be supplied in standard lengths of 12 feet.

C. Widths shall be as shown on the Drawings.

D. Fitting radius shall be 12. Side rails of straight sections and fittings shall be compatible so that standard splice plates can be used to join straight sections and fittings. Fittings shall have 3" tangents beyond the curved section to accommodate the standard splice plates.

2.4 SPLICE PLATES

A. Splice plates shall be the bolted type, using either square neck or ribbed-neck carriage bolts and serrated flange lock nuts. The resistance of fixed splice connections between an adjacent section of tray shall not exceed 0.00033 ohm. The cable tray shall be designed so that a splice plate located anywhere along the span shall not decrease the strength of the cable tray system.

B. Splice plates shall be furnished with straight sections and fittings.

2.5 ACCESSORIES

A. Covers and other special accessories shall be furnished as required to protect, support, and install the cable tray system.

2.6 LOADING CAPACITIES

A. Cable tray shall be installed to meet NEMA class descriptions for a safety factor of 1.5.

B. Cable tray shall be made to manufacturing tolerances as specified by NEMA.

PART 3 - EXECUTION

3.1 EXAMINATION AND PREPARATION

A. Cable tray and accessories shall be treated as specified in General and Special Conditions.

3.2 INSTALLATION/APPLICATION/ERECTION

A. Installation shall comply with applicable codes and manufacturer recommendations and instructions.

B. All trapezes, hangers, and supports shall be provided as required, by the Contractor, and materials shall be compatible and similar to the tray furnished.

C. Finish and install necessary restraints and sway bracing to comply with KBC requirements for applicable seismic zone.

3.3 FIELD PAINTING

A. Tray shall not be painted generally. Natural finish is acceptable.

++ END OF SECTION ++

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SECTION 26 05 53

IDENTIFICATION FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 EQUIPMENT LABELING

A. All starters, feeder units in panelboards, switchboards, disconnects, instruments, etc. shall be marked to indicate the motor, outlet, circuit they control, or variable monitored. Marking is to be done with engraved laminated nameplates and shall bear the designation shown on the Contract Drawings where this information is given. Nameplates shall be fastened to equipment with stainless steel screws, minimum of one each side. In no way shall the installation of mounting screws void the NEMA enclosure rating of the equipment in which they are installed. If there are more than one identical unit, they shall be given consecutive numbers or other descriptions as designated by the Engineer. Nameplate background color shall be white, with black engraved letters, unless otherwise noted.

B. Branch circuits in lighting panels shall be typed on a card suitable for the card frame furnished with the panel. The card shall bear the panel designation listed on the Contract Drawings where this information is given, as well as indicate what each circuit controls.

C. Individual wall mounted starters, panelboards, and disconnect switch shall be labeled with vinyl self-adhesive signs that warn of "High Voltage" (state the specific voltage) and Arc Flash. Main service entrance conduits to a building, where exposed, shall be labeled with the voltage of the service they carry. Other major equipment such as control panels, etc., shall be labeled as such. The type of labels to be used shall have orange as the basic color to conform with OSHA requirements, letters shall be black. The labels shall be of proper size to fit flatly on the surface of the enclosure to make for a neat appearance and not interfere with the operating function of the device it is attached to. These labels shall be as manufactured by the Brady Identification Systems Division, Safety Sign Company, Westline Products Company, or equal.

D. Furnish and install "Authorized Personnel Only" signs by doors into all power distribution equipment rooms/buildings. Furnish and install other signs as indicated on the Contract Drawings.

PART 2 - PRODUCTS

2.1 CONDUIT LABELS:

A. Products and Manufacturers: Provide one of the following:

1. B-915-xxxxx by Brady.
2. Or equal.

B. Shall be pre-tensioned acrylic/vinyl construction coiled to completely encircle conduit for conduit up through five-inch diameter, or pre-molded to conform to circumference of conduit six-inch diameter and larger.

C. Attach strap-on style for six-inch diameter conduit with stainless steel springs.

D. Shall be blank for use with custom printed labels.

E. Custom Labels:
1. Shall have black lettering on yellow background.
2. Shall not contain abbreviations in legend.
3. Shall be custom printed on continuous tape with permanent adhesive using thermal printer specified below.

2.2 WIRE IDENTIFICATION:

A. Heat Shrinkable Wire and Cable Labeling System:
1. White heat-shrinkable irradiated polyolefin shrink-on sleeves. Labels shall be thermal printed. Labels shall be at least two inches wide.
2. Products and Manufacturers: Provide one of the following:
   a. B-341 PS-xxx-2W by Brady.
   b. Or equal.

B. Wrap-Around Wire and Cable Labeling System:
1. Self-laminating white/transparent self extinguishing vinyl strips. Length shall be sufficient to provide at least 2.5 wraps. Labels shall be thermally printed and at least two inches wide.
2. Products and Manufacturers: Provide one of the following:
   a. THT-XX-427 by Brady.
   b. Or equal.

2.3 DETECTABLE UNDERGROUND WARNING TAPE:

A. Material: Polyethylene or polyester with detectable metal core and polyester underlaminate.

B. Width: Two inches.

C. Color and Labeling: Yellow or red with permanently imprinted black letters: "CAUTION – Buried Electric Service" or "Buried High Voltage Cable", repeated continuously over full length of tape.

D. Products and Manufacturers: Provide one of the following:
1. Indentoline by Brady.

2. Or equal.

2.4 THERMAL PRINTING SYSTEM:

A. Utilize thermal transfer process to provide non-smearing labels and markers.

B. Wire and Cable Markers:
   1. Portable, Products and Manufacturers: Provide one of the following:
      a. TLS2200 by Brady.
      b. Or equal.
   2. Desktop, Products and Manufacturers: Provide one of the following:
      a. 200M by Brady.
      b. Or equal.

C. Cable Markers:
   1. Portable, Products and Manufacturers: Provide one of the following:
      a. Handimark by Brady.
      b. Or equal.
   2. Desktop, Products and Manufacturers: Provide one of the following:
      a. Labelizer PLUS by Brady.
      b. Or equal.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Provide electrical identification in accordance with manufacturer recommendations and as required for proper identification of equipment and materials.

B. Engraved Identification Devices (Nameplates and Legend Plates):
   1. Unless otherwise specified, attach permanent nameplates with permanent adhesive and with 3/16-inch diameter, round head, stainless steel machine screws into drilled and tapped holes.
   2. Provide nameplate with 1.5-inch letters to identify each console, cabinet, panel, or enclosure as shown or indicated.
   3. Provide nameplates for field-mounted motor starters, disconnect switches, manual starter switches, pushbutton stations, and similar equipment operating components, which shall describe motor or equipment function and circuit number.
   4. Provide nameplates with 1/2-inch letters to identify each junction and terminal box shown or indicated.
   5. On switchgear, provide nameplates for each main and feeder circuit including control fuses, and for each indicating light and instrument.
      a. Provide nameplate with 1.5-inch letters giving switchgear designation, voltage rating, ampere rating, short circuit rating, manufacturer's

name, general order number, and item number.

b. Identify individual door for each compartment with nameplate giving item designation and circuit number.

6. Motor Control Centers:
   a. Provide nameplate with 1.5-inch letters with motor control center designation.
   b. Identify individual door for each unit compartment with nameplate identifying controlled equipment.
7. Except conduit, all electrical appurtenances including lighting panels, convenience outlets, fixtures, and lighting switches, shall be provided with nameplates indicating appropriate circuit breaker number(s).
8. Push Buttons:
   a. Provide legend plates for identification of functions.
   b. Provide nameplates for identification of controlled equipment.
   c. Provide red buttons for stop function.
   d. Provide black buttons for other functions.
9. Pilot Lights:
   a. Provide legend plates for identification of functions.
   b. Provide nameplates for identification of controlled equipment.
   c. Shall have lens colors as shown or indicated. Where no color is indicated, provide the following lens colors:

Color	**Legend**
Green	Running, Open
Red	Stopped, Closed
Amber	Alarm
Blue	Power
White	Status

10. Selector Switches:
    a. Provide legend plates for identification of functions.
    b. Provide nameplates for identification of controlled equipment.
11. Panel Mounted Instruments:
    a. Provide nameplates for identification of function.
12. Interiors of Cabinets, Consoles, Panels, Terminal Boxes, and Other Enclosures:
    a. Provide nameplates for identification.
    b. Provide each item inside cabinet, console, panel, terminal box, or enclosure with laminated plastic nameplate as shown on approved Shop Drawings and submittals. Install nameplates with adhesive.
    c. Interior items requiring nameplates include:
       1) Terminal blocks and strips.
       2) Bus bars.
       3) Relays.
       4) Rear of face-mounted items.
       5) Rear of door-mounted items.

6) Interior mounted items that require identification when mounted externally.

d. Circuit Breaker Directory:

1) Provide engraved laminated plastic directory listing function and load controlled for each circuit breaker within panel used for power distribution.

13. Re-label existing equipment whose designation have changed.

C. Safety Signs and Voltage Markers:

1. Provide safety signs and voltage markers on and around electrical equipment as shown or indicated.
   a. Install rigid safety signs using stainless steel fasteners.
   b. Clean surfaces before applying pressure-sensitive signs and markers.
2. Install high voltage safety signs on all equipment doors providing access to uninsulated conductors, including terminal devices, greater than 600 volts.
3. Provide cable tray safety signs on both sides of cable trays at maximum intervals of 20 feet. Install signs on side rails of tray as acceptable to ENGINEER.
   a. Label cable trays that contain conductors greater than 600 volts with high voltage safety signs.
   b. Cable trays that contain conductors greater than 208 volts and less than 600 volts shall be labeled with low voltage safety signs.
   c. Cable trays that contain conductors of 120/208 volts shall be labeled with low voltage markers.
   d. Do not label cable trays that contain only instrument signal cables.
   e. Label cable trays that contain intrinsically safe wiring or cables in accordance with NEC Article 504.
4. Install low voltage safety signs on equipment doors that provide access to uninsulated 480-volt conductors, including terminal devices.
5. Install low voltage markers on each terminal box, safety disconnect switch, and panelboard installed, modified, or relocated as part of the Work and containing 120/208 volt conductors.

D. Voltage System Identification Directories

1. Provide voltage system identification directories as required by NEC Article 210 and NEC Article 215.
2. Provide in each electrical room voltage system identification directory mounted on wall or door at each entrance to room.
3. For panelboards, switchboards, motor control centers, and other branch circuit or feeder distribution equipment that are not located in electrical rooms, provide voltage system identification directory mounted on equipment.
   a. Directories shall be affixed using epoxy glue. Screws or bolts shall not penetrate equipment enclosures.
   b. Directories shall be readily visible and not obscure labels and other markings on equipment.

E. Arc-flash Safety Signs:
   1. Provide arc-flash safety signs as required by NEC Article 110.
   2. Provide signs for switchboards, panelboards, motor control centers, and industrial control panels. Provide signs for control panels that contain 480 volt equipment.

F. Conduit Labels:
   1. Provide conduits with conduit labels unless otherwise shown or indicated.
   2. Do not label flexible conduit.
   3. Do not label exposed single conduit runs of less than 25 feet between local disconnect switches and their associated equipment.
   4. Conduit labels shall indicate the following information:
      a. Contract Number: Alphanumeric, three or four digits, as applicable.
      b. Conduit Number: Alphanumeric as shown on the Drawings, as assigned by CONTRACTOR for unlabelled conduits, and in accordance with approved submittals.
   5. Conduits that contain intrinsically safe wiring shall have an additional pipe marker provided that has blue letters on white background and reads, "INTRINSICALLY SAFE WIRING".
      a. Install intrinsically safe pipe markers in accordance with NEC Article 504 along entire installation. Spacing between labels shall not exceed 25 feet.
   6. Provide conduit labels at the following locations:
      a. Where each conduit enters and exits walls, ceilings, floors, or slabs.
      b. Where conduit enters or exits boxes, cabinets, consoles, panels, or enclosures, except pull boxes and conduit bodies used for pull boxes.
      c. At maximum intervals of 50 feet along length of conduit.
   7. Orient conduit labels to be readable.

G. Wire and Cable Identification:
   1. Color-coding of insulated conductors shall comply with Section 26 05 19, Low Voltage Electrical Power Conductors and Cables.
   2. Use heat-shrinkable wire labels where wire or cable is terminated. Use wrap-around labels where wire or cable is to be labeled but is not terminated.
   3. Do not provide labels for the following:
      a. Bare (uninsulated) conductors, unless otherwise shown or indicated as labeled.
   4. Provide wire and cable labels for the following:
      a. New, rerouted, or revised wire or cable.
      b. Insulated conductors.
      c. Wire and cable terminations:
         1) Wire labels shall be applied between 1/2-inch and one inch of completed termination
         2) Apply cable labels between 1/2-inch and one inch of cable breakout into individual conductors.
            a) Label individual conductors in a cable after breakout as

specified for wires.

d. Wire or cable exiting cabinets, consoles, panels, terminal boxes, and enclosures.
   1) Label wires or cables within two inches of entrance to conduit.
e. Wire or cable in junction boxes and pull boxes
   1) Label wires or cables within two inches of entrance to conduit.
f. Wire and cable installed in cable tray.
   1) Wire and cable shall have labels at maximum intervals of 20 feet.
g. Wire and cable installed without termination in electrical manholes.
   1) Wire and cable shall have wrap-around labels applied within one foot of exiting manhole.

5. Wire and Cable Identification System:
   a. Wire and cable labels shall be imprinted with an identifying designator.
      1) Wire and cable extending between two devices or items and that does not undergo a change of function shall be identified by a single unique designator as specified below.
   b. Field Wiring:
      1) Wire or cable designator shall consist of:
         a) Three left-most characters shall consist of the Contract number under which wiring or cable was installed.
         b) Fourth character from the left shall be an asterisk (*), a plus sign (+) or a hyphen (-). Do not use other punctuation symbols in a wire designator.
         c) Remaining characters shall be alphanumeric and make wire designator unique.
         d) Numbering shall reflect actual designations used in the Work and shall be documented in record documents.
   c. Cabinet, Console, Panel, and Enclosure Wiring, Internal:
      1) New Cabinets, Consoles, Panels, and Enclosures:
         a) Wire and cable inside cabinets, consoles, panels, and enclosures shall have designators as specified in Section 40 61 13, Process Control System General Provisions.
6. Modified Cabinets, Consoles, Panels, and Enclosures:
   a. New or rerouted wire or cable in existing cabinets, consoles, panels, and enclosures shall be labeled as shown on the Drawings or be assigned a ten-character designator equivalent to field wire designator.

H. Terminal Strip Labeling:
   1. Label panel side of terminal to match panel wire number.
   2. Label field side of terminal to match field wire number. Terminal number shall not include the Contract number.

I. Generator System Warning Signs:
   1. Provide warning signs for generator systems as required by NEC.
   2. Install generator location warning sign on or immediately adjacent to service equipment, or to "normal" source disconnecting means when generator is

located out of sight of service equipment or disconnecting means.

3. Install generator grounding warning sign on enclosure or immediately adjacent to point where generator neutral is connected to grounding electrode system if connection is made remote from generator.

J. Detectable Underground Warning Tape:

1. Warning Tape shall be placed in trenches with backfill about 12 inches below finished grade on all medium voltage underground conduit runs and others as indicated on the Contract Drawings.

+ + END OF SECTION + +

SECTION 26 05 73

ELECTRICAL POWER DISTRIBUTION SYSTEM STUDIES

PART 1 - GENERAL

1.1 SUMMARY

A. The electrical equipment manufacturer shall provide electrical power system studies as specified herein for the entire power system for the project, including existing equipment. The type and content of each study is specified in the following articles.

1.2 SUBMITTALS

A. Study Report
   1. The results of the power system study shall be summarized in a final report. Five bound copies of the final report shall be submitted for review.
   2. The report shall include the following sections:
      a. Description, purpose, basis and scope of the study and a single line diagram of that portion of the power system which is included within the scope of the study.
      b. Tabulations of circuit breaker, fuse and other protective device ratings versus calculated short circuit duties, and commentary regarding same.
      c. Protective device time versus current coordination curves, tabulations of relay and circuit breaker trip settings, fuse settings, fuse selection, and commentary regarding same.
      d. Fault current calculations including a definition of terms and guide for interpretation of computer printout.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. The specified electrical power system studies shall be performed by the manufacturer of the power distribution and control equipment furnished for the project.

2.2 ELECTRICAL POWER SYSTEM STUDIES

A. Short-Circuit Analysis
   1. Calculation of the maximum rms symmetrical three-phase short-circuit current at each significant location in the electrical system shall be made using a digital computer.

2. Appropriate motor short-circuit contribution shall be included at the appropriate locations in the system so that the computer calculated values represent the highest short-circuit current the equipment will be subjected to under fault conditions.
3. A tabular computer printout shall be included which lists the calculated short-circuit currents, X/R ratios, equipment short-circuit interrupting or withstand current ratings, and notes regarding the adequacy or inadequacy of the equipment.
4. The study shall include a computer printout of input circuit data including conductor lengths, number of conductors per phase, conductor impedance values, insulation types, transformer impedances and X/R ratios, motor contributions, and other circuit information as related to the short-circuit calculations.
5. Include a computer printout identifying the maximum available short-circuit current in rms symmetrical amperes and the X/R ratio of the fault current for each bus/branch calculation.
6. The system one-line diagram shall be computer generated and will clearly identify individual equipment buses, bus numbers used in the short-circuit analysis, cable and bus connections between the equipment, calculated maximum short-circuit current at each bus location and other information pertinent to the computer analysis.
7. A comprehensive discussion section evaluating the adequacy or inadequacy of the equipment must be provided and include recommendations as appropriate for improvements to the system.
8. The contractor shall be responsible for supplying pertinent electrical system conductor, circuit breaker, generator, and other component and system information in a timely manner to allow the short-circuit analysis to be completed prior to final installation.
9. The interrupting capacity of all over current devices shall equal or exceed the maximum fault current level where they are installed in the system. The system shall be fully rated in that the ability of the device to interrupt a fault at its terminals and shall not depend on the characteristics of an over current device upstream. Series rated devices shall not be acceptable.
10. Any inadequacies shall be called to the attention of the Engineer and recommendations made for improvements as soon as they are identified.

B. Protective Device Time-Current Coordination Analysis
1. The time-current coordination analysis shall be performed with the aid of computer software intended for this purpose, and will include the determination of settings, ratings, or types for the overcurrent protective devices supplied.
2. Where necessary, an appropriate compromise shall be made between system protection and service continuity with service continuity considered more important than system protection.
3. A sufficient number of computer generated log-log plots shall be provided to indicate the degree of system protection and coordination by displaying the

time-current characteristics of series connected overcurrent devices and other pertinent system parameters.

4. Computer printouts shall accompany the log-log plots and will contain descriptions for each of the devices shown, settings of the adjustable devices, the short-circuit current availability at the device location when known, and device identification numbers to aid in locating the devices on the log-log plots and the system one-line diagram.
5. The study shall include a separate, tabular computer printout containing the suggested device settings of all adjustable overcurrent protective devices, the equipment where the device is located, and the device number corresponding to the device on the system one-line diagram.
6. A computer generated system one-line diagram shall be provided which clearly identifies individual equipment buses, bus numbers, device identification numbers and the maximum available short-circuit current at each bus when known.
7. A discussion section which evaluates the degree of system protection and service continuity with overcurrent devices, along with recommendations as required for addressing system protection or device coordination deficiencies.
8. Significant deficiencies in protection and/or coordination shall be called to the attention of the Engineer and recommendations made for improvements as soon as they are identified.
9. The Contractor shall be responsible for supplying pertinent electrical system conductor, circuit breaker, generator, and other component and system information in a timely manner to allow the time-current analysis to be completed prior to final installation.
10. The Contractor shall be responsible for obtaining ratings of existing overcurrent devices to remain throughout the power system, to include in the coordination study.

C. Arc-Flash Hazard Analysis

1. The Arc-Flash Hazard Analysis shall be performed with the aid of computer software intended for this purpose in order to calculate Arc-Flash Incident Energy (AFIE) levels and [AP1] flash protection boundary distances.
2. The Arc-Flash Hazard Analysis shall be performed in conjunction with a short-circuit analysis and a time-current coordination analysis.
3. Results of the Analysis shall be submitted in tabular form, and shall include device or bus name, bolted fault and arcing fault current levels, flash protection boundary distances, personal-protective equipment classes and AFIE levels.
4. The analysis shall be performed under worst-case Arc-Flash conditions, and the final report shall describe, when applicable, how these conditions differ from worst-case bolted fault conditions.
5. The Arc-Flash Hazard Analysis shall be performed by a registered professional engineer.

6. The Arc-Flash Hazard Analysis shall be performed in compliance with IEEE Standard 1584-2002, the IEEE Guide for Performing Arc-Flash Calculations.
7. The Arc-Flash Hazard Analysis shall include recommendations for reducing AFIE levels and enhancing worker safety.
8. The proposed vendor shall demonstrate experience with Arc-Flash Hazard Analysis by submitting names of at least ten actual Arc-Flash Hazard Analyses it has performed in the past year.
9. The proposed vendor shall demonstrate capabilities in providing equipment, services, and training to reduce Arc-Flash exposure and train workers in accordance with NFPA 70E and other applicable standards.
10. The proposed vendor shall demonstrate experience in providing equipment labels in compliance with NEC-2008 Section 110 and ANSI Z535.4 to identify AFIE and appropriate Personal Protective Equipment classes.

PART 3 – EXECUTION

A. Manufacturer's Field Service: Engage a factory-authorized service representative of electrical distribution equipment being set and adjusted to assist in the setting of overcurrent protective devices within equipment.

B. Overcurrent devices are to be visually inspected to verify that settings determined from the final Over Current Protection Coordination Devices Study have been programmed and/or set.

C. Labels shall be applied to all enclosures, with appropriate site specific Arc Flash warnings, PPE requirements, and boundaries. Boundaries shall be painted on the floor in front of all new switchgear, switchboards, panelboards and MCC's.

D. Upon completion of field setting, provide an updated submittal on all studies updating the changes/revisions.

+ + END OF SECTION + +

SECTION 26 22 14

MEDIUM VOLTAGE POWER DISTRIBUTION

PART 1 - GENERAL

1.1 SCOPE OF WORK

A. The power distribution cabling system shall be installed in accordance with NEC and NESC requirements, and as written herein and as shown on Contract Drawings. For further information on components/installation not addressed in this article, refer to other sections of this Division, and the Contract Drawings.

B. Ends of conduits shall be sealed where they enter buildings at service equipment and empty (spare) conduits shall be capped at both ends. Spare conduits shall extend 5 feet from buildings or structures unless otherwise shown on the Contract Drawings.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Conduit
   1. Underground nonmetallic conduit shall be George-Ingraham, Ciba-Geigy, or equal. Other types of conduit for transitions to building interiors, etc., shall be as specified in 16130 - Raceways.

B. Duct Spacers and Terminators
   1. Duct spacers and terminators shall be Formex, or equal.

C. Medium Voltage Insulated Power Cables
   1. Medium voltage insulated power cables shall be Okonite, Anaconda, or equal.

D. Prefabricated Splice Kits and Terminations
   1. Prefabricated stress cones, shield grounding adapters, splice kits, and terminations hall be as manufactured Elastimold, 3M, Cooper, G&W, or equal.

2.2 MATERIALS

A. Conduit
   1. Underground duct lines for medium voltage shall be fiberglass duct or PVC, concrete encased.

B. Duct Spacers and Terminators
   1. Spacers shall be made from high density polyethylene, and shall be double wall construction. They shall consist of interlocking modules, i.e. bases, intermediates and caps. Base pads shall be used to assure specified dimensions between trench floor and bottom of first tier of ducts. The interlocking modules shall include an internal vertical channel on both side edges of the spacers. The interlocking module spacers shall provide independent support for each duct, and 3 inch separation between ducts.
   2. Terminator modules shall be made from high impact, high strength, prime virgin acrylonitrile butadiene styrene (ABS) plastic, Marbon Type G.S., or equal. Terminator module shall interlock and be sealed together using a recommended plastic solvent cement. The openings of the terminator facing the inside of the manhole shall be belled.

C. Medium Voltage Insulated Power Cables
   1. 5 KV cables shall have the following specifications:

Conductor:	Uncoated copper, stranded
Cable Arrangement:	Single conductor
Strand Screen:	Extruded, semi-conducting
Insulation:	5 KV cable 115 mils EPR
Insulation Screen:	Extruded, semi-conducting
Shield:	Uncoated copper tape, helically wrapped, 12.5% overlap
Jacket:	PVC
Temperature Rating:	105EC continuous 140EC emergency 250EC short circuit

D. Prefabricated Splice Kits and Terminations
   1. Molded Rubber Shielded Cable Splice
      a. The shielded cable splices must be capable of normal continuous operation at the rated voltage and current on the cable on which it is to be used (up to 35 KV). The splice must consist of an all-molded rubber splice body with black semi-conductive EPR rubber. All EPR rubber must be cured with a peroxide cure. All splices must be able to be installed without the use of mechanical advantage installation tools. Where required, shield adapters must be capable of quickly extending the cable shielding for outdoor, indoor, and buried applications.
   2. Molded Rubber Cable Termination
      a. The shielded cable termination must be capable of normal continuous operation at the rated voltage and current on the cable it is to be used on (up to 35 KV); and it should meet all the requirements of a Class 1 Termination as given in IEEE Standards. The termination must

consist of a high quality rubber molded stress cone made of track resistant peroxide cured EPR rubber and a one-piece silicone rubber skirted insulator for 15 KV (two-piece silicone skirted insulator for 25 and 35 KV). A mechanical (non-solder) ground strap assembly shall be included as a part of the kit. All materials (except lug) necessary to make three terminations shall be included as part of the basic 5 to 15 KV kit. This should include cable preparation materials. Additional materials may be necessary in order to convert the basic 5 to 15 KV kit into a 25 or 35 KV termination; however, the instructions packed with the kit should include all of the information as to what is needed for 25 and 35 KV.

3. Shield Grounding Adapter
   a. The shield ground adapter must be capable of use at the rated voltage of the cable it is used on, and shall be totally mechanical, requiring no soldering or taping. It shall be watertight. The housing shall be molded conductive rubber. The ground lead shall be copper. Contact with the cable shield shall be by compression of a corrugated internal contact. Compression shall be accomplished by external stainless steel clamp(s).
4. Loadbreak and Deadbreak Elbow Connectors and Accessories
   a. Insulated high voltage cable shall be terminated using deadfront elbows at padmount transformers. 200 Ampere elbows shall be loadbreak and 600 ampere elbows shall be deadbreak. Voltage class shall be 15 KV. The insulating elbows shall be molded of EPDM rubber with integral stress cones. The 200 ampere devices shall accept No. 6 - No. 4/0 conductors and the 600 ampere devices shall accept No. 2/0 - 1000 MCM conductors. Both type connectors shall be watertight and shall include all accessories needed for connection to conductor. Other characteristics:

Impulse Voltage:	95 KV BIL
Withstand Voltage:	34 KV, 60 Hz., 1 Minute
Minimum Corona Extinction Level:	11 KV
Momentary:	10,000 amps RMS Symmetrical

   b. Cable shield grounding adapters shall be furnished and installed as needed. Necessary bushing shall be furnished and installed in switches and transformers for proper mating with the elbow connectors. Feed through bushings shall be used at transformers so that deadfront arresters may be connected to the unused feed through bushing.
   c. The deadfront arrestor shall be gapless, of solid state design using a metal oxide varistor enclosed in a molded elbow similar to the elbow connector housing.

d. Furnish insulated protective caps where needed to maintain the deadfront, watertight arrangement where a bushing is unused.

E. Surge Arrestors

Surge arrestors shall comply with IEC 60099-4, and shall be provided for protection of cabling, switchgear, motor control centers, transformers and other indicated equipment. Arrestors shall be distribution class, rated as shown. Arrestors shall be equipped with mounting brackets suitable for the indicated installations. Arrestors shall be of the metal-oxide varistor type with silicone housing suitable for indoor or outdoor installations.

PART 3 - EXECUTION

3.1 INSTALLATION/APPLICATION/ERECTION

A. Duct

1. General

a. The duct system shall consist of single or multiple round-bore conduit for the electrical-distribution system. The number and size of the ducts shall be as indicated on the Contract Drawings. Duct lines shall be laid to a minimum grade of 4 inches per 100 feet. Duct shall be laid so that the top of the duct is 24 inches below finished grade or finished paving. Changes in direction of runs exceeding a total of 10 degrees, either vertical or horizontal, shall be accomplished by long sweep bends having a minimum radius of curvature of 25 feet, except that manufactured bends may be used at the ends of the run. The long sweep bends may be made up of one or more curved or straight sections and/or combinations thereof. Manufactured bends shall have a minimum radius of 18 inches for use with ducts of less than 3 inches in diameter and a minimum radius of 36 inches for ducts of 3 inches in diameter and larger. Conduits shall terminate in end bells where duct lines enter manholes. Conduit shall be thoroughly cleaned before using or laying. During construction and after the duct line is completed, the ends of the conduit shall be plugged to prevent water washing mud into the conduits or manholes. Particular care shall be taken to keep the conduits clean of concrete, dirt, and any other substance during the course of construction.

b. Where it is necessary to cut a tapered end on a piece of conduit at the site, the cut shall be made with a tool or lathe designed to cut a taper to match the taper of the particular conduit being used. After the duct line has been completed, a standard flexible mandrel not less than 12 inches long, having a diameter approximately 1/4 inch less than the inside diameter of the conduit, shall be pulled through each conduit, after which a brush with stiff bristles shall be pulled through each conduit to make certain that no particles of earth, sand, or gravel have

been left in the line. Pneumatic rodding may be used to draw in the lead wire. Where connection is made to an existing duct that is of different material and shape than the duct line being installed, a suitable coupling of a type recommended by the duct manufacturer shall be used. Conduits shall be stored to avoid warping or deterioration. Plastic conduit shall be stored on a flat surface and protected from the direct rays of the sun. Conduit joints in concrete encasement may be placed side by side horizontally but shall be staggered at least 6 inches vertically.

c. Each single conduit of the duct bank shall be completely encased in concrete. The thickness of the concrete encasement indicated is the minimum thickness, and may be increased to fit the actual shape of the trench. Duct spacers shall be used, placed on 4 feet centers. When the duct bank is assembled, a No. 3 reinforcing rod shall be passed through the internal vertical channels on one side of the spacer bank and driven into the trench floor. At the next spacer location, the No. 3 rod shall be inserted on the opposite side, etc. The reinforcing rods shall be bent inwardly at the top of the spacer bank sufficiently to squeeze the spacer cap so the duct assembly will not float or move in any direction during the concrete pour. Concrete encasement shall not be less than 3 inches on the side, bottom, and top of the conduits.

2. Couplings

a. Joints in conduit shall be made up in accordance with the manufacturer's recommendations for the particular conduit and coupling used. The plastic or fiberglass conduit joints shall be made up by brushing a plastic solvent cement or epoxy (as applicable) on the inside of the coupling and on the outside of the conduit ends. The conduit and fitting shall then be slipped together, until seated, with a slight twist to set the joint tightly, and the conduit then rotated 2 turn to distribute the cement evenly. Excess cement build up on the inside surface of the conduit shall then be removed.

B. Medium Voltage Insulated Power Cable Systems

1. The power cable systems shall consist of ethylene-propylene rubber insulated PVC jacketed conductors. The size and number of conductors shall be as indicated on the Contract Drawings. Conductors shall be stranded. Cables for use on 2,400 and 4,160 volt power systems shall be rated 5,000 volts and cables for use on 12,470 volt power systems shall be rated 15,000 volts. Cables shall be insulated to the 133 percent level. The neutral conductors of grounded neutral systems shall consist of stranded 600 volt polyethylene jacketed cables suitable for direct burial or duct shown on the Contract Drawings. Power cables shall be installed in duct lines as specified this section.

2. It is intended that cables be continuous as much as is practical without unnecessary splices. Cable splices, however, shall be made in manholes or junction boxes if necessary, and shall be installed at no extra cost to the

Owner. Cable splices and terminations shall be made up in accordance with cable manufacturer recommendations, by persons qualified to make such splices/terminations. Qualification shall consist of proof that the person(s) working on splices and terminations has at least 3 years experience with the type cables and connectors encountered on this project.

3. Cable pulling shall be accomplished using industry recognized pulling equipment and techniques, and shall be done in accordance with cable manufacturer's recommendations. All cable shields shall be grounded at both ends.

D. Prefabricated Splice Kits and Terminations

1. Splices and terminations shall be of a type appropriate for the cable type and for the environment encountered, either indoor or outdoor. All kits shall include premolded stress cones and all necessary materials needed for proper installation. The Contractor shall furnish necessary lugs, etc. for mechanical hookup from cables to equipment.
2. All terminations and splices shall be installed in accordance with manufacturer recommendations and shall be complete with all necessary accessories for an operational system. All terminations and splices shall be made prior to cable Hipot testing. All lightning arresters shall be properly grounded. All terminations in outdoor cabinets shall be treated as outdoor and terminated accordingly.

3.2 FIELD QUALITY CONTROL

A. A DC Hipot test shall be conducted on all cables before hookup and after pulling, when the cables are fitted with all terminating and splicing kits. Testing shall be in accordance with IEEE and manufacturer recommendations with test voltage for each cable as advised by the manufacturer. All cable shields shall be grounded during testing and ends of cables under test adequately insulated from grounded equipment and other equipment not under test. Submit a written report of test results to the Engineer on all cables.

B. Prior to Hipot testing, the Contractor shall utilize a high voltage megger to detect gross insulation system failure. The Hipot test on a very low quality insulated cable is destructive, and screening the cables first with the megger may prevent the Contractor replacing an otherwise salvageable cable.

C. Hipot testing shall also be performed on existing cables which have been disturbed during the course of this work.

++ END OF SECTION ++

SECTION 26 24 19

MEDIUM VOLTAGE MOTOR CONTROL

PART 1 – GENERAL

1.1 SUMMARY

A. Section includes
   1. This specification covers the design, manufacture, test, supply and delivery of medium voltage control centers, specifically, including reduced voltage solid state controllers.

1.2 QUALIFICATIONS

A. Manufacturer
   1. The manufacturer shall have a minimum of 10 years experience in the manufacture of medium voltage controllers for use in similar applications at the specified voltage and power ratings.
   2. These specifications are based on products manufactured by Allen Bradley. Other acceptable manufacturers are Benshaw and Eaton.

B. Support
   1. The manufacturer shall maintain factory trained and authorized service facilities within 100 miles of the project and shall have a demonstrated record of service for at least the previous ten years.
   2. Support personnel are to be direct employees of the manufacturer.
   3. The manufacturer shall provide all required start-up and training services.

C. Quality Assurance
   1. The control center shall be factory pre-wired, assembled and tested as a complete package by the controller supplier.
   2. All inspection and testing procedures shall be developed and controlled under the guidelines of the Supplier's quality system. This system must be registered to ISO 9001 and regularly reviewed and audited by a third party registrar.
   3. All incoming material shall be inspected and/or tested for conformance to quality assurance specifications.
   4. All sub-assemblies shall be inspected and/or tested for conformance to Supplier's engineering and quality assurance specifications.
   5. All printed circuit boards with active components shall be burned-in for a minimum of 48 hours at 60°C (140°F).

1.3 REFERENCES

A. Controller
   1. American National Standards Institute (ANSI) "Instrument Transformers C57.13"
   2. Institute of Electrical & Electronic Engineers (IEEE) (IEEE C37.20.7, Guide for Testing Arc Resistant Medium Voltage Switchgear)
   3. Electrical & Electronic Manufacturers Assoc. of Canada (EEMAC)
   4. National Electrical Manufacturers Association (NEMA) "Medium Voltage Controllers Rated 1501 to 7200V AC ICS 3-2 (formerly ICS 2-324)"
   5. Underwriters Laboratories, Inc. (UL) (High Voltage Industrial Control Equipment 347)
   6. European Directives for Safety and EMC
   7. National Electrical Code (NEC)
   8. Occupational Safety & Health Act (OSHA)

1.4 ENVIRONMENTAL REQUIREMENTS

A. Confirm to specified service conditions during and after installation of products

B. Maintain area free of dirt and dust during and after installation of products

1.5 PRE-MANUFACTURE SUBMITTALS

A. Refer to Section Division 1 for submittal procedures

B. Drawings
   1. Elevation drawings showing dimensional information
   2. Structure Descriptions showing
      a. Enclosure ratings
      b. Fuse ratings
      c. Load/line cable size and entry/exit direction
      d. Other information as required for approval
   3. Conduit locations
   4. Unit Descriptions including amperage ratings, frame sizes, pilot devices, etc.
   5. Nameplate Information
   6. Schematic wiring diagrams

C. Product Data
   1. Publications related to the controller(s)
   2. Data Sheets and Publications on all major components such as the following
      a. Contactors
      b. Circuit Breaker and Fuse information including time current characteristics

c. Control Power Transformers
d. Pilot devices
e. Relays
f. Operator Interface

D. Spares
1. Recommend spare parts list and list prices shall be supplied.
2. Critical Spares - Spare parts that are identified as being associated with long lead times and/or are critical to the unit's operation.
3. Maintenance Spares - Spare parts that are identified as being required to regularly perform scheduled maintenance on their equipment. These spares include, but are not limited to, consumable spares that are required to be exchanged during scheduled maintenance periods.

E. Specification Response
1. Detailed response to this specification showing where in the literature and drawings each requirement is satisfied.
2. All clarifications and exceptions must be clearly identified.

F. Testing and Test Reports
1. Testing shall be per manufacturer's standard.
2. A copy of the test reports shall be provided as part of the Closeout documentation, if requested.

1.6 CLOSEOUT SUBMITTALS

A. Refer to Section Division 1 for procedure on submittal of closeout documentation.

B. Contractor shall provide certification that the controller has been installed in accordance with the manufacturer's instructions.

C. The Contractor shall provide certification that the Contractor has properly adjusted any timing devices required in the starting circuitry.

D. Final Drawings. The manufacturer shall provide final drawings reflecting the "As-Shipped" status of the controller. The Contractor shall be responsible for making any changes to the "As-Shipped" drawings from the manufacturer to reflect any field modifications.

E. Maintenance Data
1. Controller installation instructions and User Manual
2. Installation / Operation instructions for major components such as circuit breakers, contactors, isolation transformers, etc.
3. Field Service report from start-up service
4. Spare parts listing and pricing
5. Include name and phone number for a local distributor of spare parts.

1.7 DELIVERY, STORAGE AND HANDLING

A. Contractor shall coordinate the shipping of equipment with the manufacturer.

B. Contractor shall store the equipment in a clean and dry space according to manufacturer's specification.

C. The contractor shall protect the units from dirt, water, construction debris and traffic.

1.8 FIELD MEASUREMENTS

A. The Contractor shall verify all field measurements prior to the fabrication of the controller(s).

1.9 SPARE MATERIALS

A. Fuses
   1. Provide a minimum of one set (3) of each type of medium voltage fuse supplied with the controller for each set of five installed.
   2. Provide a minimum of one set of each type of low voltage fuse supplied with the controller for each set of five installed.

B. Contactors
   1. Provide one set of 3 contactor vacuum bottles for each size of medium voltage vacuum contactor supplied with the controller.
   2. Provide one spare vacuum contactor control module (IntelliVAC).

C. Isolation Switch
   1. Provide one spare isolation switch blade assembly for each amp rating installed.
   2. Provide one spare isolation switch auxiliary contact for each set of five installed.
   3. Provide one spare isolating switch cam follower for each type installed.
   4. Provide one spare isolating switch stationary stab for each amp rating installed.

D. Provide one spare motor protection relay for each type supplied with the controller.

E. Provide one spare overload relay supplied with the controller.

F. Provide one spare control relay for each type of relay supplied with the controller.

G. Provide one spare MOV assembly of each type supplied with the controller.

H. Furnish all cables required for connection to the controllers with a laptop, and all software necessary for configuration and programming.

1.10 WARRANTY

A. The manufacturer shall provide their standard parts warranty for a minimum of one year from the date of project Substantial Completion.

B. The manufacturer shall confirm this warranty as part of the submittal.

PART 2 – PRODUCTS

2.1 RATINGS

A. Voltage
   1. The controller shall accept nominal plant power of 2400V at 60Hz.
   2. The supply input voltage tolerance shall be plus or minus 10 percent of nominal line voltage.
   3. The supply frequency tolerance shall be plus or minus 3 percent.

B. Environmental Ratings
   1. Storage ambient temperature range: -20 C to 75 C (-4 to 149 degrees F).
   2. Operating ambient temperature range: 0 C to 40 C (32 to 104 degrees F) without derating.
   3. The relative humidity range is 0% to 95% non-condensing.
   4. Operating elevation: up to 1,000 Meters (3,300ft) without derating.

2.2 STRUCTURE

A. The structure shall consist of a metal enclosed free-standing dead-front vertical steel assembly.

B. The structure shall also have a non-removable base channel and removable lifting means for ease of installation.

C. The controller(s) shall be designed for front access to allow for installation with no rear access. Equipment that requires rear or side access for installation shall not be accepted.

D. Enclosure
   1. Controller enclosures shall be NEMA Type 1A, with door gaskets

2. The enclosure shall be properly sized to dissipate the heat generated by the controller at its full ratings within the limits of the specified environmental operating conditions.
3. LV door latches shall be heavy-duty ¼-turn type units.
4. Medium Voltage doors shall be held closed using 3/8" bolts.
5. All back plates shall be removable.

E. Low Voltage Wireway
1. A low voltage wireway, shall be available across the roof at the front of the structure.
2. The low voltage wireway shall provide a convenient method of interconnecting control wire from one controller to another.
3. Low voltage wireway shall be separated from MV and LV control compartments.

F. Structure Finish
1. All exterior metal parts (except for low voltage panel and power cell back plates) shall be painted with hybrid epoxy powder paint ANSI 49 medium light gray.
2. All mounting plates in the power cell and low voltage compartments shall be painted high gloss white for enhanced visibility.
3. Painting shall be done on a continuous paint line through air-atomized electrostatic spray. All parts shall be painted before assembly.
4. The preparation shall be Alkaline wash/rinse; iron phosphate rinse; iron-chrome sealer rinse; re-circulated de-ionized water rinse and virgin de-ionized water rinse
5. Total paint thickness – 0.002" (0.051 mm) minimum
6. Baking process shall be by Natural gas oven at 179°C (355°F) minimum.
7. All unpainted steel parts shall be plated with a zinc plate/bronze chromate process for corrosion resistance.

G. Nameplates
1. Provide master nameplate for controller.
2. Provide unit nameplates.
3. Provide legend plates for all pilot devices.
4. Nameplates plates shall be engraved phenolic (1.125 inches x 3.625 inches) with black background and white lettering.

H. Seismic Qualifications
1. The equipment shall be bolted down (mounted) per the Manufacturer's recommended installation instructions.
2. The properly installed equipment shall be capable of withstanding horizontal and vertical accelerations in accordance with KBC requirements, without overturning or lateral movement.

2.3 POWER AND GROUND BUS

A. Bus Bracing
   1. The horizontal/vertical buswork and the cabling/bus in the main power cell(s) shall be braced and tested in accordance with NEMA ICS 3-2 and UL 347.
   2. The bus work and cabling shall be braced to withstand the let-through energy allowed by the largest fuse during a short circuit fault.
   3. The horizontal bus fault withstand current rating shall be 60 kA RMS symmetrical for 10 cycles.
   4. The vertical bus fault withstand current rating shall be 50 kA RMS symmetrical for one half cycle.

B. Horizontal Bus
   1. The main horizontal power bus shall be located in the center, at the back of the structure, to provide optimum heat distribution, ease of maintenance and splicing.
   2. To provide better short-circuit withstandability and to protect against the accumulation of dust and tracking between phases, the power bus shall be mounted on edge to a molded bus support insulator in a common vertical plane.
   3. The power bus shall be made of tin-plated copper and shall have a continuous current rating of 2000A. The main power bus will be non-insulated.
   4. Access plates shall be provided to the bus compartment from the front or the rear of the structure to allow for installation and regular maintenance of the power and ground bus splice connections.
   5. The horizontal buswork, the cabling/bus from the main power cell shall be braced and tested in accordance with NEMA ICS 3-2 and UL 347 (paragraph 30).

C. Vertical Bus
   1. Provide vertical power bus risers from the main horizontal power bus to the isolating switch line terminals.
   2. The vertical risers shall be tin-plated copper.
   3. Cabling from the main horizontal power bus to the isolating switch is not acceptable.

D. Ground Bus
   1. A continuous copper ground bus shall be provided along the entire length of the controller line-up.
   2. A mechanical lug for #8 to #1/0 AWG or #6 to 250 MCM cable shall be supplied at the incoming end of the line-up.
   3. The ground bus shall be 1/4" x 2" (6.4 x 51 mm), bare [tin-plated] copper.

2.4 MAIN UNIT

A. The withstand rating of the main shall be greater than or equal to the bus bracing for the controllers.

B. The main breaker shall be compact design which will fit it the space identified.

C. The main breaker shall be a three position draw out type with disconnect, test, and connect positions and spring loaded primary disconnects and breaker control switch.

D. The breaker shall be rated for up to 20,000 operations.

E. The assembly shall be furnished with a drawout tray, levering-in crank, and lifting yoke.

F. LED indicating lights shall be provided for indicating breaker position.

G. Provide lugs to accommodate the line conductors as indicated on the drawings.

H. Provide metal oxide station type surge arrestors.

2.5 FEEDER DISCONNECT

A. Provide feeder disconnects with overcurrent protection as indicated on the drawings.

B. The disconnect shall be a fused load break switch.

C. A quantity of (3) current limiting power fuses shall provide the overcurrent protection.

D. Units shall be provided in two high construction for units rated 400 Amps and below.

E. The feeder disconnect unit shall consist of three isolated compartments.
   1. Power Bus Compartment
   2. Power Cell
   3. Low Voltage Panel
   4. The functional compartment specifications shall follow the motor specification where applicable.

F. Provide (3) load cable terminals

2.6 SMC UNIT DESIGN

A. The controller shall be manufactured by a single vendor. The medium voltage,

solid-state controller shall be mounted in the MCC lineup as described herein..

B. The controller shall be of modular design to provide for ease and speed of maintenance. The modules are to be manufactured by one supplier, designed to allow ease of maintenance, including removal of medium voltage components and power electronic components.

C. The structure shall be divided into isolated compartments as follows:
   1. Main power bus and ground bus compartment
   2. Power cell compartment
   3. Low voltage compartment

D. Metal or glass polyester barriers shall be provided between the low voltage compartment and the power cell and/or main power bus compartment, and between the power cell and main power bus compartment. Personnel shall have access to the low voltage compartment, with the controller energized, without being exposed to any medium voltage.

E. Vacuum Contactor Specifications (Input And Bypass)
   1. The electrically held medium voltage contactor shall be the Allen-Bradley model 1502 vacuum type or equivalent
   2. The following current ratings shall be available:
      a. 400 A
      b. 800 A
   3. The contactor shall have visual contact wear indicators. No special tools are required for checking contact wear.
   4. Vacuum bottle and coil maintenance shall be performed on the contactor while it is mounted. Removal of contactor is not required.

F. Isolation Vacuum Contactor
   1. The vacuum input contactor shall be fixed mounted inside the power cell. Fixed mounting provides solid, continuous contact, lowering maintenance requirements considerably. The contactor shall be interlocked with the non-load-break isolating switch, both electrically and mechanically, which shall provide the following safety features:
      a. Prevent the isolating switch from being opened or closed when the contactor is in the closed position.
      b. Prevent the opening of the medium voltage door when the isolating switch is in the closed position.
      c. Prevent the closing of the isolating switch when the medium voltage door of the controller is open.
      d. Remove control power from the control power transformer (CPT), power transformers (PTs) or external power source to the control circuit when the isolating switch and contactor are in the open position.

G. Bypass Vacuum Contactor
   1. A contactor shall be provided to bypass the SCRs once the motor is up to full speed. When a stop option is selected, the bypass contactor will open, bringing the SCRs back into the power circuit. It shall be fixed mounted in the main power cell.
   2. The bypass contactor shall be capable of providing a full voltage start in case of emergency bypass.

H. Control Wire Specification
   1. The control wire shall be an insulated (with a flame retarding thermoplastic compound), flexible stranded, tinned copper wire supported and neatly bundled. Red wire shall indicate AC power, blue wire shall indicate DC power and green wire shall indicate ground. Other colors or combinations may be used for specific applications. The control wire shall be isolated from high voltage components in the power cell (whenever possible), and wire tube markers which are numbered according to the electrical diagram, shall be provided at each end of the wire.
   2. All of the control wire terminations shall be a screw-type, copper-compression-type terminal block or connector which firmly grips the conductor. Non-insulated, locking-type, fork tongue lugs shall be provided on the control wire terminating on the control power transformer(s) and current transformers.

I. LOW VOLTAGE CONTROL PANEL
   1. Each controller shall have a separate, front accessible, low voltage control compartment. The compartment shall be completely isolated, using metal barriers between the low voltage compartment and the power cell and/or main power bus compartments for utmost safety.
      Optional meters, motor protection relays, selector switches, operators, indicating lights, etc., shall be mounted on the front of the low voltage control panel, and arranged in a logical and symmetrical manner. The low voltage panel shall provide the following features:
      a. Space shall be provided for low voltage control devices, transducers and metering.
      b. There shall be necessary terminal blocks supplied. Extra terminal blocks can be supplied as an option.
      c. There shall be low voltage control panel access without turning the controller "OFF" when opening the low voltage control panel door.
      d. All remote low voltage cables shall be able to enter from the top or bottom of the structure. Access to the wireways shall be by means of removable entry plates on the top and bottom of the structure.
      e. As standard, the combination controllers shall incorporate a swing-out low voltage panel which provides easier access to the power cell to make bus splicing and load cable connections. All products shall have a swing-out low voltage panel, which is interlocked with the power cell compartment (the panel shall not have the ability to swing open

until the power cell is "OFF" and isolated from the main power bus) to allow easy access to medium voltage equipment, i.e. power stacks, power bus, power factor correction capacitor, or other similar equipment.

f. Pilot control relays shall be used to operate and economize the vacuum contactor.
g. The control panel supply voltage shall be 120 V AC, 50/60 Hz. It shall be rectified to provide a DC operating voltage for the vacuum contactor coils and economizing relay.
h. There shall be a two-pole, three-conductor (with a grounding prong) male plug to provide a means for connecting a two-pole, three-conductor receptacle from a remote 120 V AC, 50/60 Hz supply to operate the control circuit when it is in the TEST position (combination controllers only).
i. The low voltage control panel door shall have a viewing window, allowing the user to monitor the MV SMC-Flex controller operation via the built-in display.

J. INTERLOCKING

1. Mechanical interlocking, including cable interlocks, horizontal and vertical ram interlocks, shall be provided to prevent the opening of any power cell door or medium voltage compartment until the non-load-break isolating switch is fully in the open position and power is removed (the external operating handle must be in the OFF position).
2. Optional key interlocks configured to operate with the operating handle or power cell door shall be available when interlocking is required with another specified device, i.e. main breaker, load-break switch, starter, etc.

K. POWER FUSES AND FUSE HOLDERS

1. R-rated current limiting power fuses shall be provided. R-rated fuses shall be used for the short circuit protection of medium voltage motors and motor controllers.
2. The medium voltage product shall have fixed power fuse holders that are separately mounted in the power cell, not on the contactor, and be located to allow easy inspection and replacement without any disassembly. The power fuses shall have a spring actuated blown fuse indicator. The power fuse size shall be selected when motor data and the protective device characteristics are known.

L. CONTROL POWER TRANSFORMER

1. The control power shall be 110/120 V AC, and shall be obtained from a control power transformer (CPT) located in each controller power cell, or from a separate control source. The dry-type CPT shall be sized as required for the control system load, plus 350 VA extra capacity for the customer's use when the standard control circuit is supplied and shall have primary and

secondary fuses.

2. The secondary circuit of the transformer(s) shall be disconnected from the control circuit by means of the isolating switch auxiliary contacts. This is to prevent backfeeding through the transformer(s) and to isolate the power cell when the control circuit is in the TEST mode.
3. The standard control power transformers used in the controller shall be a compensated type with an output accuracy of approximately 4% over nominal at no load. They shall be designed to maintain voltage at in-rushes of up to 600%, which results in a 2% overvoltage at full load.

M. PRIMARY FUSES

1. The primary side of the control power transformers and/or potential transformers shall be protected by current limiting fuses sized according to requirements. The interrupting rating of the primary fuses shall be 50 kA symmetrical.

N. SECONDARY FUSES

1. The secondary side of the control power transformer and/or potential transformers shall be fused appropriately to protect the transformer(s) from overloads. The standard control circuit shall have one leg of the secondary grounded.

O. CURRENT TRANSFORMERS

1. The medium voltage power cell shall include three (3) current transformers of sufficient VA capacity to meet the requirements of all the devices connected to them.
2. Each current transformer shall have the primary rating sized appropriately in relation to the full load current rating of the motor or feeder. The secondary of the current transformers shall have a five (5) amp output and an accuracy suitable for the type and quantity of protection or metering devices connected to it. All current transformer control wiring shall be terminated on the current transformer with locking type, fork tongue lugs.
3. An appropriate load termination location shall be provided to accommodate lugs with single or two-hole mounting, for connection of the load cables, when either bar or donut type current transformers are supplied.
4. The power cell shall have provisions to locate a toroid (donut) style, ground fault sensing current transformer, when the zero sequence ground fault protection feature is required (Combination Controller only).

P. CONTROL MODULE • LOGIC DESIGN FEATURES

1. Mechanical
   a. The control module shall be designed for mounting within the low voltage panel (for safety reasons) and shall be compatible with the full range of current and voltage ratings.
   b. The control module shall consist of a power supply, logic control

circuitry, silicon controlled rectifier (SCR) firing circuitry, I/O circuitry, a digital programming keypad, a backlit LCD display, and a serial communication port.

2. Programming and Display
   a. Digital parameter adjustment shall be provided through a standard built-inkeypad. Analog potentiometer adjustments are not acceptable. A built-in backlit LCD display shall be provided for controller set-up, diagnostics, status, and monitoring. The display shall be three-line, 16-characters minimum.
   b. The display shall be capable of depicting alphanumeric characters in any of the following languages, by adjustment of a single parameter:
      1) English
      2) French
      3) Spanish
      4) German
      5) Portuguese
      6) Mandarin
3. Communications
   a. A serial communications port DPI (Drive Programming Interface), shall be provided as standard. Optional communications protocol interface modules shall be available for connection to Remote I/O, DeviceNet™, ControlNet™, Ethernet, RS-485, and Profibus-DP.
4. Electrical
   a. The control module shall provide closed-loop digital microprocessor control and supervision of all controller operations, including SCR pulse firing control. The control module shall be the same as used for the SMC-Flex low voltage product family.
5. SMC-Flex Control Modes
   a. The control module shall offer the following functions:
      1) Soft Start -with Selectable Kickstart
      2) Soft Stop
      3) Current Limit Start -with Selectable Kickstart
      4) Dual Ramp -with Selectable Kickstart
      5) Full Voltage
      6) Preset Slow Speed
   b. Pump Control
      1) The Pump Control option shall be implemented to provide closed loop control of a motor to match the specific torque requirements of centrifugal pumps for both starting and stopping. This shall aid in eliminating the phenomena commonly referred to as "water hammer". Methods utilizing Soft Start and Soft Stop shall not be acceptable.
      2) Closed loop control shall be achieved without using external sensors or feedback devices.
      3) The Pump Start time shall be user adjustable from 0 to 30 seconds.

4) Pump Stop shall be initiated by a dedicated Pump Stop input. A coast-to-rest stop shall still be possible with a separate stop input.
5) The Pump Stop time shall be user adjustable from 0 to 30 seconds.
6) Extended Pump Start or Stop times may be made available, upon consultation with qualified factory personnel.
7) Kick-start shall provide an adjustable time pulse of current prior to the normal start mode. The current shall be controlled to provide 0-90 % of locked rotor torque for a time between 0.0 and 2.0 seconds. This feature shall be field selectable.

6. SMC-Flex Monitoring
   a. The controller shall provide the following monitoring functions indicated though the built-in LCD display; or remotely via the communication port:
      1) Phase-to-phase supply voltage
      2) Three-phase line current
      3) Three-phase power (MW, MWh, power factor)
      4) Elapsed time
      5) Motor thermal capacity usage
      6) Motor speed (with optional use of tachometer input)
7. SMC-Flex Protection and Diagnostics
   a. The following protection and diagnostics shall be provided as standard with the controller:
      1) Power loss (with phase indication; pre-start)
      2) Line fault (with phase indication; pre-start) advising: –Shorted SCR
      3) Missing load connection
      4) Line fault (running protection) advising: –Power loss –Shorted SCR
      5) Voltage unbalance *
      6) Phase reversal *
      7) Undervoltage *
      8) Overvoltage *
      9) Stall *
      10) Jam *
      11) Overload *
      12) Underload *
      13) Excessive starts/hour *
      14) Open gate (with phase indication)
      15) Overtemperature (power stack, with phase indication)
      16) Communication loss
      17) Motor temperature (via PTC input)

      * These protective features shall be selectable.
   b. Overload Protection shall include:
      1) The control module shall meet applicable standards as a motor overload protective device
      2) Three-phase current sensing shall be utilized; the use of two current transformers shall be unacceptable.
      3) Overload trip classes of 10, 15, 20 and 30 shall be provided and

user-programmable.

4) Electronic thermal memory shall be provided for enhanced motor protection
5) Protection shall be available through the controller while in bypass configuration
6) Separate overload relay shall be provided for emergency bypass operation

Q. SCR POWER CIRCUIT DESIGN
1. The SCRs shall be protected from voltage transients with an R-C snubber network to prevent false SCR firing.
2. The SCRs shall be protected from overvoltage with voltage threshold gating circuitry.
3. The SCR firing circuitry shall be fully isolated from the control circuits. Fiber optic cables shall be used for isolation from the logic circuits.
4. Current loop gate driver boards shall be utilized to increase efficiency of the controller, reducing power consumption and heat.

2.9 UNIT MODIFICATIONS

A. Motor Run Time Meter
1. Provide a digital, non-resettable, door-mounted elapsed time meter.
2. The meter shall have six digits with tenths.
3. The meter shall be electrically interlocked with the contactor to indicate actual motor operating hours.

B. Low Voltage Surge Suppressors
1. Provide low voltage surge suppressors across each 120 V coil in the control circuit.

C. Metering
1. Main Switch or Incoming Section
   a. Provide a digital metering system.
   b. The metering system shall consist of a monitoring unit and display module. The unit shall be shipped with the necessary current transformers and potential transformers.
   c. Monitoring Unit
      1) The monitoring unit shall be Multilin PQM, or equal.
      2) The monitor shall have the following metering capability
         a) Phase current (A-B-C) with plus or minus 0.2 percent accuracy
         b) Average three phase current and neutral current with plus or minus 0.2 percent accuracy
         c) Phase to phase and phase to neutral voltages with plus or minus 0.2 percent accuracy
         d) Current and voltage unbalance

e) Power functions kW, kVA and kVAR with plus or minus 0.4 percent accuracy
f) Demand functions kW and kVA with plus or minus 0.4 percent accuracy
g) Energy functions kWH and kVAH with plus or minus 0.4 percent accuracy
h) Power factor with plus or minus 0.4 percent accuracy
i) Frequency with plus or minus 0.05 percent accuracy
j) Distortion analysis with THD, Crest Factor (I, V) and Distortion Power Factor.
k) Maximum metering update rate of 50ms.

3) The monitor shall have a control relay output.
4) The monitor shall be ANSI/IEEE tested to meet or exceed the Surge Withstand Capability (SWC) C37.90.1 – 1989 for protective relays and relay systems on all power connection circuit terminations.

d. Display Module
1) The display module shall have a highly visible LED display.
2) The display shall be five inches square and designed to fit into a circular cut-out that is four inches in diameter.
3) The display shall be utilized for viewing data and for programming of the monitoring unit.

e. Potential Transformers
a) A common set of two (2) PT's shall provide voltage reference for one MCC line-up.

2. Controllers
a. Provide switchboard type (4 ½ inch) metering.
b. Provide analog ammeter with ammeter switch.
c. Provide analog voltmeter with voltmeter switch.
d. Provide (3) current transformers.
e. Provide (2) potential transformers with primary and secondary fusing.

3. Feeder Units
a. Provide switchboard type (4 ½ inch) metering.
b. Provide analog ammeter with ammeter switch.
c. Provide analog voltmeter with voltmeter switch.
d. Provide (3) current transformers.
e. Provide (1) potential transformer with primary and secondary fusing.

D. Pilot Devices
1. Pilot devices shall be Allen-Bradley Bulletin 800H (NEMA Type 4/4X/13) and shall be mounted on the enclosure door.
2. For motor starter provide pilot lights, mounted on the enclosure door, for indication of ON, OFF and OVERLOAD. Pilot lights shall be transformer type.

E. Terminal Blocks

1. Provide ten additional unwired terminal blocks in each unit.
2. Allen-Bradley type 1492 or equal.

F. Auxiliary Relays
1. Provide auxiliary control relays as indicated on the drawings.
2. The relays shall be Allen-Bradley 700P or 700CF relays or equal.

G. Power Factor Correction Capacitors
1. Power factor correction capacitors shall be provided for each controller in the MCC, sized to correct the power factor to 0.95%.
2. Contactors shall be provided ahead of the capacitors, and interlocked with the shorting contactor, to prevent energizing until the controller has completed the ramping sequence and the shorting contactor is closed.
3. The capacitors shall be furnished with fusing and overload protection.
4. Provide cooling fans as required.

2.10 MOTOR PROTECTIVE RELAY

A. The motor management relay shall provide primary protection and management to medium voltage motors. The relay shall be equipped with the following protection functions.
1. Motor Thermal Overload Model (49)
   a. Include 15 standard overload curves, a custom curve feature, and a curve specifically designed for the starting of high inertia loads, when the acceleration time exceeds the safe stall time.
   b. The stator protective thermal model shall combine inputs from phase and unbalance currents, and RTD winding feedback. This will then cause the model to become dynamic in nature in order to follow the loading and temperature of the motor.
   c. Motor cooling time constants
   d. Rotor protection during stall and acceleration. To achieve this a speed switch input shall be available.
2. The relay shall detect ground faults or earth leakage currents as low as 0.25 A using a 50:0.025 Ground CT.
3. Use phase and unbalance current heating to calculate motor thermal capacity during starting and running states
4. Settable motor stopped and motor running cooling time constants
5. Phase and residual overcurrent elements (50P/50G)
6. Unbalance / single phase biasing (46)
7. Load-loss (undercurrent) (37)
8. Mechanical jam (48)
9. Motor stall protection
10. Re-start blocking timer to be used as a start permissive to ensure the motor had slowed to a safe speed or to a complete stop, before it can be re-started again

11. Antibackspin protection ensuring that the motor can only be re-started when it has slowed to within acceptable limits. A backspin detection voltage input shall be provided to measure frequency. If the measured frequency is below a programmed minimum threshold, the backspin start inhibit shall be removed
12. Starts-per-hour (66)
13. Minimum-time-between-starts
14. The relay shall provide an option for voltage transformer inputs, which shall be used to provide overvoltage (59), undervoltage (27), voltage phase reversal (47), overfrequency (81O) and underfrequency (81U) functions
15. The relay shall be equipped with an Undervoltage Auto-restart function that will restart the motor after an undervoltage trip caused by a momentary loss of power.
16. 12 RTD inputs with associated over-temperature protection functions including alarm and trip settings, with corresponding settable time delays, and associated outputs. The following additional functionality shall be provided, associated to RTDs:
    a. Able to configure each of the twelve RTDs as "None" or any one of four application types: "Stator", "Bearing", "Ambient", or "Other"
    b. RTD type shall be selectable between four different RTD types: "100 Ohm Platinum", "120 Ohm Nickel", "100 Ohm Nickel", or "10 Ohm Copper"
    c. The motor relay shall incorporate the RTD inputs to support the following:
        1) Thermal overload model biasing
        2) Temperature alarms and trips (49/38)
        3) RTD open- or short-circuit alarm
    d. The motor relay shall include trip voting for extra reliability in the event of RTD malfunction. If enabled, a second RTD must also exceed the trip temperature of the RTD being checked before a trip is issued
    e. Provisions shall be included to allow the RTDs to be identified by name
17. The relay shall be able to monitor up to four remote RTD modules, each with 12 RTD inputs, with associated over-temperature protection functions including alarm and trip settings, settable time delays, and associated outputs. Additional functionality shall be identical to that provided by the on board RTDs as describer above.
18. Protection functions associated to Power, which include alarm and trip settings, with corresponding settable time delays, and associated outputs:
    a. Power Factor (55)
    b. Reactive Power
    c. Under Power (37)
    d. Reverse Power

B. The relay shall operate with either wye-connected (four wire) or open-delta-connected (three wire) potential transformers, and three phase, four wire connected current transformers.

C. The relay shall include provisions to allow its use in conjunction with variable frequency drives. All of the elements shall function properly with the exceptions of voltage and power elements.

D. The motor protection relay shall have five (5) output relays, and six (6) digital inputs. The output relays shall be as follows: Trip Relay, Alarm Relay, two auxiliary relays, and a service relay. Five of the six digital inputs shall have the following pre-assigned default functions:
   1. Access Switch to allow changing of any setpoint values from the face plate,
   2. Differential Switch to accept inputs from an external differential protection relay
   3. Emergency Restart to allow a hot motor to be restarted
   4. External Reset, to allow resetting trips or latched alarms
   5. Speed Switch to accept a trip signal from a speed monitoring device

E. Although assigned default functions, these five inputs, along with the one remaining spare input, can be user programmable to alternate functions. The function that the input is used for may be chosen from the following list of functions: Starter Status configured for either an 'a' or 'b' auxiliary contact, Waveform Capture, Digital Counter, DeviceNet Control, and General Switch functions in which an alarm and/or trip may then be configured for that input. The relay shall be able to monitor the digital inputs of up to four remote RTD modules.

F. The relay shall allow motor starting and stopping via any of the communication ports. When a Stop command is sent the TRIP relay shall be activated for 1 second to complete stop sequence. When a Start command is issued, an output relay shall be assigned for starting control, which shall be activated for 1 second to complete the start sequence. The Serial Communication Control function shall also be used to reset the relay and activate a waveform capture.

G. The relay shall be capable of protecting the motor during the entire starting process in Reduce Voltage starting applications.

H. The relay shall provide complete monitoring and metering functions. These shall include:
   1. Current: Phasors, RMS Values of per Phase, Average, Motor Load, Current Unbalance, Unbalance Biased Motor Load, Ground, Differential Currents
   2. Voltage: Phasors, RMS Values of Phase-Phase and Phase-Neutral, Average Voltage

3. Frequency
4. Temperature of each RTD Inputs
5. Motor Speed (RPM)
6. Power: Power Factor, Three phase Real (kw, hp), Reactive (kvar), Apparent (kva) Power
7. Energy: Watt-hours, Var-hours
8. Demand: Rolling Demand method, time interval, programmed to 5 to 90 min in steps of 1 minute
9. An event recorder with a record of the last 512 events, time tagged with a resolution of 10 ms.
10. The waveform capture feature is similar to a transient/fault recorder. The relay shall storage of up to 16 cycles of data, captured for Phase A, B, and C currents (Ia, Ib, and Ic), Ground currents (Ig), Phase A-N, B-N, and C-N voltages (Van, Vbn, and Vcn) for wye connections, Phase A-B and B-C (Vab and Vbc) for open-delta connections
11. The relay shall be able to provide data in the form of trending or data logger, sampling and recording up to eight actual values at an interval defined by the user. Several parameters shall be trended and graphed at sampling periods ranging from 1 second up to 1 hour. The parameters which can be trended by the Setup software shall be: Phase Currents A, B, and C, and Average Phase Current, Motor Load, Current Unbalance, Ground Current, System Frequency, Voltages Vab, Vbc, Vca Van, Vbn & Vcn, Power Factor, Real (kW or hp) Reactive (kvar), and Apparent (kVA) Power, Positive Watt-hours, Positive and Negative Var-hours, Hottest Stator RTD, Thermal Capacity Used, RTDs 1 through 12 temperature, Remote RTDs 1 through 12.
12. The relay shall include four transducer outputs with a settable DC output range of 0 to 20 mA, 4 to 20 mA or 0 to 1 mA, which may be assigned to any measured parameter. The range of these outputs shall be scalable.
13. The relay shall be able to monitor up to four remote RTD modules, each with four Analogue Outputs, with settable DC output range and functionality identical to the on board Analogue Outputs. The remote RTD Module Analogue Outputs shall be assigned to any temperature measured by the module RTDs.
14. Latest trip report containing date and time, cause, phase, ground, motor load, current unbalance, Line-Line and Line-ground voltages, hottest stator RTD, system frequency, real, reactive and apparent power, and power factor
15. Alarm status information reflecting Alarm Name as programmed and status.
16. Start block timer status including overload lockout, start inhibit, starts per hour, time between starts, and restart block

I. The Motor Learned Data shall capture up to 250 sets of motor starting values, averaged over up to five motor starts. The motor learned data must be graphically

represented through a PDF report. The following is the learned data captured and stored and can also be printed and filed.

1. Learned Acceleration Time
2. Learned Starting Time
3. Learned Starting Capacity
4. Learned Running and Cool Time Constant
5. Learned Stopped Cool Time Constant
6. Learned Unbalance K Factor
7. Learned Average Motor Load
8. Learned Run Time After Start
9. Date of last learned Date average calculation or last record

J. The relay must provide a high-speed data logger to capture analog signals during motor starting conditions. A total of six individual logs (1 baseline and rolling buffer of last 5 starts), each 30 seconds long are available to record key analog quantities at a sampling rate of 200 milliseconds. The following information shall be captured.

1. General:
    a. True RMS Phase A, B and C Currents
    b. Phase Current Unbalance
    c. True RMS Ground Current
    d. True Phase to Phase or Phase to Ground Voltages
    e. Thermal Capacity Accumulated (%)
    f. System Frequency
    g. Breaker / Contactor Status
2. Preventive Maintenance Information:
    a. The relay shall keep count of number of trips by type
    b. Number of motor starts or start attempts
    c. Number of Emergency Restarts
    d. Motor running hours
    e. Autorestart start attempts
    f. Time to autorestart
    g. Digital input counters

K. The relay shall have starter failure detection feature which shall produce an alarm in the event that the motor relay does not detect a starter/breaker open condition after a trip is initiated.

L. The relay shall have the capability to display up to 5 user programmable text messages.

M. Under normal conditions, if no front panel activity is detected within a settable time, the screen shall sequentially display up to 30 default messages. Any actual value or setpoint message shall be selectable for default display.

N. Security / Change History Report

The relay must comply with NERC CIP security reporting requirements and provide traceability. The relay must maintain a history of the last changes made to the configuration, including modifications to settings and firmware upgrades. A summary history of the last ten sessions and a list the last 100 specific setting changes made must be recorded and stored in non-volatile memory. The report must be available to be saved and printed in PDF format.

1. Security Setting Reports shall include the following information:
2. Dates and times of security setting changes
3. MAC address of user making setting changes
4. Listing of modified changes
5. How setting changes were made (Keypad, Front serial port, Ethernet)

O. User interfaces shall include:
   1. A 40 character LCD display, and navigation keys
   2. Indicator LEDs on the front panel which shall provide a quick visual indication of status
   3. A front panel RS232 serial port that shall provide easy computer access. The communications protocol shall be Modbus RTU
   4. Two rear RS485 ports. The communications protocol shall be Modbus RTU
   5. An RS485 communications port shall be provided specifically designed to communicate to Remote RTD modules. The relay shall be capable of communicating with up to four Remote RTD modules. Access to the remote RTD modules for setpoints and actual values shall be achieved through the motor relay via any of the available communication ports. The remote RTD communication port standard media shall be a three terminal port. Optional media shall be fiber optic, with a maximum baud rate of 19.2 kBs, fiber sizes 50/125, 62.5/125, 100/140, and 200 µm, and emitter fiber type 820 nm LED, multimode.
   6. An optional RJ45 Ethernet port shall be provided to allow 10BaseT Ethernet connectivity to Local or Wide Area Networks. The communications protocol shall be Modbus TCP
   7. An optional terminal port shall be provided to allow DeviceNet or Profibus connectivity to Local DeviceNet or Profibus Networks.
   8. The relay shall be capable of being set by Windows-based, Easy to use, Setup graphical terminal interface
   9. To make the data acquisition more efficient, the motor relay shall provide a User Definable Memory Map, which shall allow a remote computer to read up to 125 nonconsecutive data registers by using one Modbus packet. The User Definable Memory Map shall be programmed to join any memory map address to one in the block of consecutive User Map locations, so that they can be accessed by means of these consecutive locations. The User Definable area shall have two sections:

a. A Register Index area containing 125 Actual Values or Setpoints registers
b. A Register area containing the data located at the addresses in the Register Index

P. A testing feature shall be included to allow testing analogue outputs and relays, without the need for external voltage and current inputs.

Q. The relay shall be capable of being programmed through a windows based software program that is capable of the following:
1. The software program will operate in the following fashion
   a. Request system and motor nameplate data from user through display screens.
   b. Generate cautionary notes based on inputted information
   c. Generate settings file
   d. Review settings with user with the option to disable any configured settings that are not required
   e. Provide PDF report outlining the settings that have been generated, as well as any cautionary notes required
   f. Report and Settings file to be saved in user-selectable location
2. The following system and protection settings will be generated based on inputted information
   a. All CT, VT and Power System settings
   b. All Thermal Model settings including
      1) Short Circuit
      2) Mechanical Jam
      3) Unbalance
      4) Undercurrent
      5) Ground Fault
   c. All Motor Start / Inhibit protections
   d. Local RTD configuration, alarming and tripping
   e. Under / Over Voltage
   f. Under / Over frequency
   g. Phase Reversal
   h. Local Digital input for 52A / B contact
   i. All other settings will have default values
3. Include Typical Wiring Diagram based on CT / VT type
4. Provide a summary of all enabled settings in a PDF format that can be saved or printed.

R. Motor Health Report

The Motor Health Report included with the relay will provide a detailed history of the operation and performance of the associated motor in both graphical and data format. The following information will be provided in the Motor Health Report.

The report can either be saved to a location in a soft copy or be printed in PDF format.

The report shall be divided into seven categories and provide the following information:

1. Device Summary
    a. Requested Period
    b. Report Created By
    c. Motor Name
    d. Protection Device
    e. Firmware Version
    f. Motor FLA
    g. Rated Voltage
    h. Phase Rotation
    i. System Frequency
    j. Motor Running Time
2. Status Overview
    a. Provide historical learned date of the following
    b. Acceleration Time
    c. Starting Current
    d. Starting Capacity
    e. Motor Load
    f. Run Time After Start
3. Trip Summary
    a. Overload / Thermal
    b. Current
    c. Voltage / Frequency / Power
    d. Miscellaneous
    e. Information shall be represented both graphically and numerically
4. Motor Operating History
    a. The Motor Operating History will provide information extracted from the Events Record
    b. Motor Start / Running
    c. Manual Stop Command
    d. Trip Command
    e. Lockout
    f. Alarm Conditions
    g. Emergency Restarts
    h. Information shall be represented both graphically and numerically
5. Motor Starting Learned Information
    a. Learned Data will be captured for every motor start
    b. 250 Learned Data Records will be stored in the relay
    c. Learned Acceleration Time
    d. Learned Starting Current
    e. Learned Starting Capacity
    f. Learned Average Motor Load

g. Learned Average Run Time After Start
h. Information shall be represented both graphically and numerically

6. Motor Start Data Logger
   a. The Motor Start Data Logger consists of Baseline Record and 5 additional records
   b. Each record shall contain 6 channels of information
   c. Each channel shall contain 150 samples, sampled at 200ms intervals for a total of 30 seconds
   d. Information to be included in the Motor Start Data Logger:
   e. Average Current
   f. Average Current Unbalance in Percent
   g. Ground Current
   h. Average Voltage
   i. Thermal Capacity Used
   j. Frequency
   k. Breaker Status
   l. Information shall be represented both graphically and numerically
7. Motor Stopping / Tripping
   a. Events that are related to the stopping or tripping of the motor
   b. Overload Trip
   c. Mechanical Jam
   d. Short Circuit
   e. Under Power
   f. Current Unbalance
   g. RTD Temperature
   h. Ground Fault
   i. Under/Over Voltage
   j. Under/Over Frequency
   k. Manual/Remote Stop
   l. Information shall be represented both graphically and numerically

S. To help extend product life, and to protect the motor protection relay from hostile and harsh environments including moisture, temperature variations, salt spray, organic attack (fungus), and aggressive chemicals and vapors, the product manufacturer shall provide optional harsh environment conformal coating.

T. The motor protective relay shall be the Multilin 369, or equal.

PART 3 – EXECUTION

3.1 MANUFACTURE TESTING AND INSPECTION

A. Standard Testing
   1. The following tests shall be carried out in accordance with applicable requirements and/or specifications of Canadian Standards Association

(CSA), Underwriters Laboratories (UL), National Electrical Manufacturers Association (NEMA), European Standard (EN), and International Electrotechnical Commission (IEC).

2. Start-up of the medium voltage motor control equipment shall be coordinated with the start-up of the driven equipment, and other related equipment which may pertain to drive settings. The controller field service representative shall be available during the entire start-up procedure to adjust settings as required for the entire system operation.
2. Functional checks shall be performed wherever possible; otherwise, inspection and continuity checks shall be made.
3. A "HI-POT" dielectric withstand test shall be performed on all buswork and cables from phase-to-phase and phase-to-ground (except solid-state components, low voltage controls and instrument transformers). The voltage level used for this test depends on the product's nominal AC voltage.
4. Component devices shall be functionally operated in circuits as shown on electrical diagrams or as called for by specific test instructions.
5. Instruments, meters, protective devices and associated controls shall be functionally tested by applying the specified control signals, current and/or voltages.
6. Medium Voltage starters shall be inspected for the following:
    a. Electrical interlocking
    b. Motor protection and ground fault if applicable

B. Physical Inspection
1. The product must meet all applicable engineering and workmanship standards and specifications. All components shall be verified against engineering documentation to be present and correctly installed.
2. All bus and bus connections shall be checked for proper clearance, creepage, phasing, and torque.
3. Warning plates, isolation barriers, and mechanical interlocks must provide sufficient safety/isolation for personnel and equipment.
    a. Warning labels and nameplates must be present and in their specified positions to advise personnel of possible hazards.
    b. Isolation barriers must be in place within the cabinet. Such barriers protect personnel from touching live medium voltage components in an area that otherwise does not have power supplied to it.
    c. Operation of isolation switch handle and door interlocks must be verified. The interlocking prevents the opening of any medium voltage door on a medium voltage cabinet when the isolation switch handle has been moved to the full ON position.

3.2 MANUFACTURE'S FIELD SERVICES

A. The service division of the controller manufacturer shall perform all start-up services. The use of third party supplier start-up personnel is not allowed.

B. Start-up personnel shall be direct employees of the controller manufacturer.

C. At a minimum, the start-up service shall include:
   1. Pre-Installation Meeting
      a. The start-up plan
      b. The start-up schedule
      c. Installation requirements
   2. Pre-Power Check
      a. Inspect the starter's mechanical and electrical devices enclosed
      b. Perform a tug test on all internal connections within the starter and verify wiring.
      c. Verify critical mechanical connections for proper torque requirements.
      d. Verify and adjust mechanical interlocks for permanent location.
      e. Confirm all sectional wiring is connected properly.
      f. Re-verify control wiring from any external control devices.
      g. Set up auxiliary equipment with customer supplied parameters.
      h. Confirm cabling of starter to motor and line feed.
      i. Megger Motor Resistances.
   3. Power-up and Commissioning
      a. Apply medium voltage to the starter and perform operational checks.
      b. Exercise the starter in Test Mode (combination controllers).
      c. Run the starter motor system throughout the operational range to verify proper performance.
   4. Record of all measurements

3.3 TRAINING

A. An authorized factory representative shall provide training in accordance with Section 26 05 05, General Provisions for Electrical Systems.

B. The manufacturer shall outline the training session duration and content.

C. The basis of the training shall be the controller, the engineered drawings and the user manual.

D. The instruction shall include the operational and maintenance requirements of the controller.

E. At a minimum, the training shall:
   1. Review of the engineered drawings identifying the components shown on the drawings.
   2. Review starting / stopping options for the starter.
   3. Review starter and contactor hardware.
   4. Review the maintenance requirements of the controller.
      a. Hardware replacement procedures
      b. Power device replacement procedures

c. Fault analysis and troubleshooting
d. Preventative maintenance procedures

5. Review safety concerns with operating the controller.

+ + END OF SECTION + +

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SECTION 26 27 26.13

LOW VOLTAGE WIRING DEVICES

PART 1 - GENERAL

1.1 SCOPE OF WORK

A. Wiring devices shall be installed where indicated on the Contract Drawings.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. "Hubbell," "Wiremold," "P&S," "Leviton," "Daniel Woodhead," or equal.

2.2 EQUIPMENT

A. General
   1. Sump pumps shall be equipped with the proper cord and plug for receptacles.
   2. Switch and receptacles for sump pump motors shall be rated at 20 amps at 125 volts and shall be equipped with a manual motor starting switch in lieu of toggle switch, as specified elsewhere this division.

B. Receptacles
   1. Twin-convenience - outlet (interior) – "Hubbell" Cat. No. 5362GRY, or equal.
   2. Twin-convenience - outlet (exterior) – "Hubbell" Cat. No. 5362GRY, with Taymac Corporation or Intermatic, Inc., safety outlet enclosure.
   3. Special purpose outlet - Per equipment requirements.
   4. Single receptacle for sump pump - 20A/125 VAC – "Hubbell" Cat. No. 2310, or equal.
   5. Ground fault interrupting receptacles shall be required where shown on the Contract Drawings, and shall be indicated by the abbreviation "GFI" beside the circuit symbol on the Contract Drawings. They shall be rated 20 amps (125 volts) and shall be of the duplex, feed through type, capable of protecting all downstream receptacles on the same circuit. They shall be UL listed and interrupt the current between 4-6 milliamps of ground fault leakage. Appropriate plates shall be furnished and installed. The 20 ampere rating shall apply not only to device internals but to the faceplate as well. Device shall be "Hubbell" Cat. No. GF5362GRY, or equal.

C. Plates and Covers
   1. Furnish and install plates of the appropriate type and size for all wiring and control devices, signal and telephone outlets.
   2. All plates on surface mounted boxes shall be of 302 stainless steel (nonmagnetic) with rounded or beveled edges, except in pump rooms, pipe galleries, and pipe trenches, then weatherproof covers shall be installed. All plates on flush mounted boxes shall be stainless steel. All device plate screws shall be stainless steel with countersunk heads. Plates shall be installed vertically and with an alignment tolerance of 1/16 inch. Device plates shall be of the one-piece type, of suitable shape for the devices to be covered. Plates shall have a smooth finish with no crevices to collect dirt. Oversize plates are not acceptable.
   3. Covers for boxes serving equipment where flexible conduit is to be tapped into cover plates shall be sheet metal drilled for conduit. Gaskets shall be required as well as all special adapters for mounting.

D. Wall Switches (Tumbler Type)
   1. Single pole (interior) – "Hubbell" Cat. No. 1221GRY, or equal.
   2. Single pole (exterior) – "Hubbell" Cat. No. 1222GRY, or equal, and Bryant 7420 or equal plate.
   3. 3-way switches (interior) – "Hubbell" Cat. No. 1223GRY, or equal.
   4 4-way switches (interior) – "Hubbell" Cat. No. 1224GRY, or equal.

PART 3 - EXECUTION

3.1 INSTALLATION/APPLICATION/ERECTION

A. Wall Switches
   1. Wall switches shall be mounted at a height as indicated in Section 26 05 05, General Provisions for Electrical Systems, unless otherwise noted on the Contract Drawings.

B. Receptacles
   1. Outlets shall be located as shown on the Contract Drawings. Where located in special interior finishes, they shall be properly centered. Boxes shall be of the type noted and accepted for the specific installation.
   2. Furnish and install receptacle circuits where called for on the Contract Drawings and/or by these Specifications. Circuits shall be installed in conduit from panel to receptacle, with flush mounted boxes except as noted on the Contract Drawings.
   3. Receptacles and lighting circuits shall not be combined on the same overcurrent device. For runs over 75 feet or for 30 amp receptacles, minimum wire size shall be AWG No. 10.
   4. Receptacles for specific devices (i.e., sump pumps), shall be rated at the correct voltage and amperage for that unit.

5. The minimum free length of conductor at each box for the connection of a fixture, switch or receptacle shall be 8 inches. All connections shall be made mechanically and electrically secure.
6. Receptacles shall be duplex type, rated at 20 amps, 125 volts, gray colored, unless otherwise noted. Mounting height shall be as specified for low outlets in Section 26 05 05, General Provisions for Electrical Systems, except in pipe galleries and pump rooms subject to floods, where they shall be medium height. All receptacles shall be of the grounding type.
7. Receptacles over workbenches or countertops or at medium or high mountings shall be mounted so that the grounding slot is below the neutral and hot. All other receptacles shall be mounted with the grounding slot above the neutral and hot.
8. Weatherproof receptacles, shall be weatherproof while in use. This requirement shall apply on all outdoor units and on others as indicated on the Drawings. To meet this requirement, appropriate safety outlet covers as manufactured by Taymac Corporation, Intermatic Guardian Series, or equal shall be utilized in these areas.
9. Wiring devices in wet locations shall bear a weather resistant mark per UL Listing.

+ + END OF SECTION + +

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SECTION 26 29 01

MOTORS

PART 1 - GENERAL

1.1 DESCRIPTION

A. Scope
1. Motors are to be furnished with driven equipment except where otherwise noted on the Contract Drawings or elsewhere in this Division of the Specifications. All motors shall conform to the following Specifications and any special requirements of the driven equipment. Special requirements of the driven equipment shall take precedence over these Specifications should a discrepancy occur. Starting torque and slip ratings shall conform to the requirements of the driven equipment.
2. Polyphase motors shall be of the squirrel cage induction type and single phase of the capacitor start-induction run type except as otherwise noted. Conduit boxes shall be tapped for the size conduit shown on the Contract Drawings.
3. All motors shall be manufactured and installed in accordance with applicable NEMA standards and NEC provisions, latest revisions.

B. Related Sections:
1. Section 43 21 40, Vertical Turbine Pumps

1.2 REFERENCES

A. Standards referenced in this Section are:
1. ASTM A48/A48M, Specification for Gray Iron Castings.
2. IEEE 112, Test Procedure for Polyphase Induction Motors and Generators.
3. IEEE 522, Guide for Testing Turn-to-Turn Insulation on Form-Wound Stator Coils for Alternating Current Electric Machines.
4. IEEE 1043, Recommended Practice for Voltage Endurance Testing of Form-Wound Bars and Coils.
5. NEMA MG 1, Motors and Generators.
6. ANSI/NETA ATS, Acceptance Testing Specifications for Electrical Power Equipment and Systems
7. UL 1004, Electric Motors.

1.3 QUALITY ASSURANCE

A. Qualifications:
1. Manufacturer:
a. Manufacturer shall have not less than five years experience producing equipment substantially similar to that required and shall be able to submit documentation of at least five installations in satisfactory

operation for at least five years each.

1.4 SUBMITTALS

A. Action Submittals: Submit the following:
   1. Shop Drawings:
      a. Data sheets indicating nameplate data for fractional-horsepower motors.
      b. Outline drawing or data sheet indicating complete motor dimensions for motors rated greater than 1/3-hp. Several motors of the same type and rating for the same application may be covered by an appropriate single drawing or data sheet. Drawings and data sheets shall have complete identifying data including frame size, speed, horsepower ratings, and application for each particular motor.
      c. Details of motor heaters, winding thermal protection, and other accessories.
      d. Copies of motor characteristic curves and data inputs when required for programming motor protection and management relays.
   2. Product Data:
      a. Submit motor test data sheets for each motor rated one horsepower or greater. Values indicated on test data sheets shall be from tests of a previously manufactured, electrically duplicate motor or calculated data. Mark each test data sheet to indicate the Project motor application location, manufacturer, type, frame size, horsepower, voltage, speed, bearing type, lubrication medium and enclosure type. Test data sheet shall also include:
         1) Winding resistances.
         2) Torques.
         3) Efficiencies.
         4) Power factors.
         5) Slip.
         6) Full load amperes.
         7) Locked rotor and no load amperes.
         8) Nameplate temperature and results of dielectric tests.
   3. Testing Plans and Procedures:
      a. When witnessed source quality control testing is required in the Section for associated driven equipment, submit description of proposed shop testing methods, procedures, and testing apparatus with calibration dates, together with proposed testing schedule and proposed travel and logistical plans for testing.

B. Informational Submittals: Submit the following:
   1. Manufacturer's Instructions:
      a. Instructions and recommendations for handling, storing, protecting the motors.
      b. Installation data for motors, including setting drawings, templates, and

directions and tolerances for installing anchorage devices.

2. Source Quality Control Submittals:
   a. Written reports presenting results of required shop testing. Shop test reports shall be dated and signed by motor manufacturer.
   b. When witnessed shop tests are required, shop test results shall be signed by and shall bear the seal of registered professional engineer. Name on seal, registration or license number, and jurisdiction or registration of license shall be legible.
3. Field Quality Control Submittals:
   a. Written reports presenting results of required field testing and inspections. Field testing reports shall be dated and signed by CONTRACTOR.
4. Supplier Reports:
   a. Submit written report of results of each visit to Site by Supplier's service personnel, including purpose and time of visit, persons contacted, problems encountered and resolved, tasks performed, results obtained, and other pertinent information. Submit within two days of completion of visit to the Site.
5. Qualifications Statements:
   a. Submit manufacturer's qualifications data when requested by ENGINEER.

C. Closeout Submittals: Submit the following:
   1. Operation and Maintenance Data:
      a. Furnish operation and maintenance data for motors as part of the operations and maintenance data for the associated driven equipment.
      b. Comply with Section 01 78 23, Operations and Maintenance Data.

D. Maintenance Material Submittals: Submit the following:
   1. Spare Parts and Extra Stock Materials: For each motor size and type, furnish spare parts in accordance with motor manufacturer's recommendations, including the following for three-phase motors:
      a. One set of fans and guards for each set of three or fewer motors, for each size of totally-enclosed fan-cooled motor.
      b. One set of bearing liners, or renewable ball or roller bearings, for each set of three or fewer motors, for each type and size of motor.
      c. One set of oil rings, for each sleeve bearing motor.
      d. One set of bearing temperature detectors, for each set of three or fewer motors, of each type of motor.

1.5 DELIVERY, STORAGE, & HANDLING

A. All electrical motors shall be protected against the accumulation of moisture, dust and debris and physical damage during the course of installation of the job. Motors shall be shipped with openings sealed.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Motors – "U.S. Motors", "Baldor", "Marathon", "Reliance", or equal.

2.2 EQUIPMENT

A. General:
   1. Ratings and Electrical Characteristics
      a. Time: All motors shall be rated for continuous duty.
      b. Temperature: Based on NEMA standards for a maximum ambient temperature of 40 degrees Celsius and an altitude of 3,300 feet or less, according to service factor and insulation class employed.
      c. Voltage: The new motor specified herein shall be rated for 2300 volts. All motors shall be capable of normal operation at balanced voltages in the range of ±10 percent from rated winding voltage.
      d. Frequency: All a-c motors shall be rated for 60 Hz. operation. All motors shall be capable of normal operation at frequencies 5 percent above or below the nominal rating of 60 Hz.
      e. Horsepower: Horsepower of the motors shall be as shown on the Contract Drawings.
      f. Locked Rotor Current: Locked rotor current shall be in accordance with NEMA standards.
      g. Efficiency and Power Factor: Efficiency and power factor shall be given consideration during Shop Drawing review. The ratings at full, 3/4, and 1/2 load shall be compared to similar motors manufactured by acceptable suppliers listed in these Specifications. Excessive variation shall be considered grounds for rejection.
      h. Speed: Synchronous speed of motors shall correspond to standard NEMA ratings. Actual speed shall be as given in the Specification Division on the driven equipment. Slip shall not exceed 5 percent at full load.
      i. Service Factor: The service factor shall be 1.0 unless requirements of the driven load necessitate a higher service factor.
      j. Insulation Class: Insulation shall be NEMA Class B, except as otherwise noted. Submersible motors shall be Class F, and motors to be operated at variable speed shall be Class F. Class F insulated motors shall operate at a Class B rise at nameplate horsepower loading.
      k. Design Level: Motors shall be NEMA design B, except as otherwise noted.
      l. Inverter Duty Rating: Motors used for variable frequency drive applications shall be inverter duty rated. Motors used for variable

frequency drive applications shall comply with the performance standards of NEMS MG 1-31.

m. Insulated Bearings: Motors over 100 hp used for variable frequency drive applications shall be furnished with insulated or ceramic bearings.

n. Shaft Grounding Kit: Motors used for variable frequency drive applications shall be furnished with a shaft grounding ring kit.

o. Frame Size: Frame designations shall be in accordance with NEMA standards.

p. Winding Overtemperature Sensors: All motors 15 horsepower and over shall be provided with motor winding thermostats. The devices shall be hermetically sealed, snap-acting thermal switches, actuated by a thermally responsive bi-metallic disk. A minimum of 1 per phase is required, with switches wired into the control circuit of the starter to provide de-energization should overheating threaten.

2. Mechanical Characteristics

a. Integral Horsepower Motor Construction

1) Motor frames for vertical motors shall be cast iron, heavy fabricated steel, or extruded aluminum (alloy 6063-T4 or 6063-T6). Endshields for vertical motors must be cast iron.

2) If an aluminum frame is used, the endshields and/or all other steel hardware must be plated with zinc or cadmium and coated with grease before assembly to minimize the galvanic action between the steel and aluminum.

3) Motor frames and endshields shall be of such design and proportions as to hold all motor components rigidly in proper position and provide adequate protection for the type enclosure employed. Lifting lugs of all motors shall conform to NEMA standards.

4) Windings shall be random or form wound, adequately insulated and securely braced to resist failure due to electrical stresses and vibration. If the windings are aluminum, there shall be a cold welded aluminum-copper transition joint at the termination of the windings to permit the use of standard copper to copper connection techniques by the electrician and to prevent galvanic action between the copper power wires and the aluminum windings.

5) The motor shaft shall be made of high grade machine steel or steel forging of size and design adequate to withstand the load stresses normally encountered in motors of that particular rating. Bearing journals shall be ground and polished.

6) Rotors shall be made from high grade steel laminations adequately fastened together and to the shaft. Rotor cage windings may be cast aluminum of bar type construction with brazed end rings.

7) Integral horsepower motors shall be equipped with cone, roller, or ball bearings made to AFBMA standards, Grade 1 and shall be of ample capacity for the motor ratings. The bearing housing shall be large enough to hold sufficient lubricant to minimize the need for frequent relubrication (ten years normal operation without lubrication), but facilities shall be provided for adding new lubricant and draining out old lubricant without motor disassembly. The bearing housing shall have long, tight running fits or rotating seals to protect against the entrance of foreign matter into the bearings or leakage of lubricant out of the bearing cavity.

3. Tests, Nameplates, and Shop Drawings
   a. Tests
      1) Tests shall be required on integral horsepower motors only. The test shall be certified by the factory and shall contain a statement to the effect that complete tests affirm the guaranteed characteristics published in the manufacturer's catalogs or descriptive literature.
      2) Tests will be in accordance with IEEE test procedures.
   b. Nameplates
      1) Each motor shall have a permanently affixed nameplate of brass, stainless steel, or other metal of durability and corrosion resistance. The data contained on the nameplate shall be in accordance with NEMA standards.
   c. Shop Drawings
      1) Shop Drawings shall consist of motor dimensions, nameplate data from each motor and tests as outlined above. Also included shall be efficiency and power factor at 100, 75, and 50 percent load. Operation, maintenance, and lubrication information (including bearing catalog numbers) shall be submitted with Shop Drawings for review.
4. Efficiency Requirements
   Motors shall meet full load efficiency ratings per NEMA MG1, Table 52 for premium efficient motors.

B. Motors Over 200 Horsepower
   1. Motors specified in this section shall comply with the requirements of preceding Section 2.2, Sub-article A unless otherwise noted herein. Motors shall be furnished by the pump supplier to be installed by the Contractor. Terminal housings shall be as specified in Sub-article D which follows, and extra long motor leads shall be provided to accommodate the large terminal housing.
   2. Motors shall be vertical , solid shaft, NEMA Design B, (with NEMA P base). Motors shall be especially suitable both electrically and mechanically to drive the equipment specified in other divisions. The speed, horsepower, torque, base, bearings, shaft and motor tolerances shall

be coordinated closely with the equipment manufacturer's requirements so as to provide a satisfactory, efficient drive without overloading, overheating, or abnormal vibration.

3. Motors shall meet the NEMA temperature rise as defined for Class B insulation. Service factor shall be 1.15 and the motor shall be tested for temperature rise at its service factor load above a 40 degree C ambient. All motors shall be dynamically balanced and vibration shall be measured per NEMA methods. Critical speed of the shaft and motor assemble shall be above the operating speed of the motor by at least 10 percent.
4. Motor enclosure shall be NEMA WP I with non-hygroscopic encapsulated windings. Screens shall be provided over all frames and endshield openings.
5. Motors shall be equipped with nonreverse ratchets to prevent damage to pumps.
6. Bearings shall be selected to have AFBMA rated minimum life of 1 year when operating continuously at rated speed of the motor and at total load consisting of the weight and hydraulic thrust load imposed on the motor by the pump. Angular contact ball thrust bearings, spherical roller thrust bearings, or plate thrust bearings shall be used depending on thrust requirements. Motors shall have oil lubricated thrust and guide bearings, with visual level indicators, accessible drain plugs and accessible filling plugs. Oil lubrication system shall be so designed as to provide the correct quantity of lubricant with minimum foaming or aeration. A nameplate shall be provided on all motors showing bearing numbers and oil type and required viscosity.
7. Motors shall be high thrust capable of carrying 30 percent momentary upthrust. High thrust motors shall be furnished with angular contact ball bearings.
8. In addition to the test report required in the preceding Sub-article, the manufacturer shall submit data indicating: guaranteed efficiencies and power factor at 100 percent, 75 percent, and 50 percent load; full load current; locked rotor current.
9. Motor Construction
    a. The stator winding insulation system shall be Class B. The insulation system shall be of non-hygroscopic materials and processes which provide high resistance to moisture, temperatures, and contaminants as generally experienced in applications of this nature.
    b. The maximum temperature rise of Class B insulated windings as measured by the resistance methods, shall not exceed 80 degrees Celsius when the motor operates continuously at rated nameplate horsepower, voltage and frequency with an ambient temperature not exceeding 40 degrees Celsius.
    c. The motor shall be capable of successful operation under running conditions with variations from rated voltage and rated frequency in accordance with NEMA Standard MG1-20.45.

d. The stator winding and end turn connections shall be sufficiently braced to withstand repeated full voltage starts. The bracing system shall essentially eliminate coil vibration under the high current conditions of starting as well as during normal operation. If a tied bracing system is used, it shall be such that no tie depends upon the integrity of any other tie within the system.

e. The squirrel-cage of the rotor shall be of cast or fabricated aluminum preferably, although fabricated copper or copper alloy shall be acceptable. The material and construction selected shall be unaffected by moderately corrosive atmospheres containing chlorine, hydrogen sulfide, and methane found in wastewater treatment facilities.

f. Rotor surface losses shall be minimized by the use of thin, high strength steel laminations. The rotor shall have provisions for convenient touch-up balance in the field after final installation if necessary.

g. The motors shall be equipped with suitable corrosion-resistant guard screens.

10. Bearings and Couplings

a. Each motor shall be equipped with two end shield bearings of the sleeve type. Where necessary, the bearings shall be insulated to prevent shaft currents and resulting bearing damage. Sleeve bearings shall be ring-oiled with an adequate integral self-cooled oil reservoir whenever possible. The bearing sleeves shall be lined with a high tin content babbitt to minimize oil contamination. Close running shaft seals shall prevent oil leakage as well as prevent entrance of foreign material, such as water and dirt, into the bearing area. Oil level sight gages with permanently marked-easily discernable oil level shall be provided. Inspection openings to observe oil ring operation shall be provided.

b. Each motor shall be direct-connected to the equipment through a flexible coupling suitable for imposed load torque and end-thrust.

11. Protective Devices

a. Each motor shall be provided with two resistance temperature detectors per phase. Each shall possess 10 or 120 ohms resistance, shall be embedded in the stator windings, and their leads brought out to a suitable termination.

b. The control circuit will include a monitoring relay as specified elsewhere in these Specifications.

c. Surge capacitors shall be furnished, mounted in the motor conduit box and connected to the motor phase leads. These connections shall be provided by the motor manufacturer.

d. Lightning arrestors shall be provided, mounted in the motor conduit box and connected to the motor phase leads. These connections shall be provided by the motor manufacturer.

Lightning arrestors shall be designed specifically for rotating machine protection.

e. Provide a bearing temperature detector for each motor bearing. Each shall be of the resistance temperature detector type with 10 or 120 ohms resistance.

12. Terminal Boxes and Terminations
    a. Motor supply cables shall be shielded and shall terminate in stress cones.
    b. Terminal boxes shall be cast iron or fabricated steel, neoprene gasketed and bolted with adequate space for connections. The motor leads shall be permanently marked in agreement with connection diagram. Separate water-tight terminal boxes shall be provided for connection of the thermal protective circuit.
13. Motor Nameplate
    a. Each motor shall have a stainless steel nameplate which shall indicate the motor connection diagram and shall also give the following information: type, frame, insulation class, HP, full load current, RPM, Celsius degree rise, manufacturer's name and serial number, model, voltages, locked rotor KVA code, and bearing numbers.
14. Tests
    a. General
        1) Each motor shall be given a routine factory certified test as defined in NEMA Standards to determine that it is free from electrical or mechanical defects and to provide assurance that it meets design specifications.
        2) One motor shall be subjected to a complete IEEE test consisting of full load heat run, percent slip, locked rotor current, breakdown torque (calculated), starting torque, winding resistance, high potential, efficiencies and power factors at 100, 75, 50, and 25 percent of full load, and bearing inspection.
        3) All motor components and accessories shall be in place for motor shop testing. All test variables shall conform to actual field values and shall be maintained throughout all tests. Any lubrication leaks, excessive noise, and overheating shall be corrected prior to shipment. In case of failure of any unit to meet test requirements and specified performance, the motor manufacturer shall make such alterations as are necessary and the tests shall be repeated without additional cost to the Owner until the equipment is satisfactory.
    b. Vibration Requirements
        1) Testing shall demonstrate that the vibration with the motor bolted to a steel floor, stator at design temperature, motor shaft extension with half-key, and lubrication at normal operating temperature shall not exceed 0.10 inches/second at rotational

frequency and at all multiples through 120 Hz and one-half of rotational frequency or 0.15 inches/second unfiltered. Vibration shall be as measured in any plane on bearing caps of both ends.

2) Stator temperature for vibration tests may be accomplished by restricting cooling air flow or by other industry standard methods; however, the motor manufacturer shall evaluate all effects of the method of testing, and vibration readings shall be taken while air flow is not restricted. During the testing, the motor shall be complete and shall have nothing removed for convenience except the power lead conduit box.

PART 3 - EXECUTION

3.1 INSTALLATION/APPLICATION/ERECTION

A. Installation of motors shall comply with motor manufacturer instructions as well as applicable NEMA recommendations and requirements of the driven equipment OEM (original equipment manufacturer).

B. Motors shall be aligned to acceptable tolerances and shall not vibrate excessively.

C. Shaft grounding ring kits shall be bolted directly to the motor end bracket to ensure ground connection to the motor frame.

3.2 FIELD QUALITY CONTROL

A. Site Tests:
   1. Inspect motors prior to supplying electricity to (energizing) equipment. Do not energize equipment without ENGINEER's permission. Inspections shall include the following:
      a. Inspect motor and equipment for physical damage.
      b. Inspect motor for proper anchorage, mounting, grounding, connection, and lubrication.
      c. Check for unusual noise and indications of overheating during initial or test operation.
   2. Perform testing at the Site for motors larger than 200 hp, as follows:
      a. Testing shall be witnessed by ENGINEER.
      b. Initial inspections and testing shall include the following:
         1) Electrical and grounding connections.
         2) Shaft alignment, proper mounting and lubrication.
         3) Check ventilating air passageways for blockage.
         4) Excessive noise.
         5) Overheating.

6) Correct rotation.
7) Protective detectors operation.
8) Excessive vibration.
9) Space heater operation.

c. Electrical testing shall include the following:
1) Insulation resistance test.
2) Surge comparison test.
3) Vibration test.
4) Bearing insulation resistance test on insulated bearings.
5) Running current and voltage measurements and evaluations relative to load conditions over full range of operations and nameplate full-load amperes.
6) High-potential test.
7) For wound rotor motors, additional testing at minimum and normal operating load points and at ring short.
8) Motor operation with the driven equipment for not less than 48 continuous hours per motor, with checks for overheating and vibration during operation.

d. Tests and values shall be in accordance with motor manufacturer's recommendations and ANSI/NETA ATS.

e. Prepare and submit field testing report in accordance with ANSI/NETA ATS.

B. Manufacturer's Services:

1. For motors larger than 200 hp, furnish services of motor manufacturer's qualified service representative to assist with installing motors, checking installed motors before initial operation, assisting in performing field quality control tests and inspections, observing and assisting initial operations, and training operations and maintenance personnel in caring for, operating, and maintaining motors. The representative shall make a minimum of 4 visits to the site per motor with a minimum 4 hours on-site for each visit. Manufacturer's representative shall test operate the system in the presence of the ENGINEER and verify that the equipment conforms to the requirements. Representative shall revisit the Site as often as necessary until all trouble is corrected and the installation is entirely satisfactory. All costs, including travel, lodging, meals and incidentals, for additional visits shall be at no additional cost to the OWNER.

2. Preparing and submitting manufacturer's field report for each visit to the Site.

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SECTION 26 29 23

MEDIUM VOLTAGE VARIABLE FREQUENCY DRIVES

PART 1 GENERAL

1.1 SUMMARY

A. Section includes

1. This specification covers materials, equipment and start-up services required to place into operation an integrated medium voltage variable frequency drive (VFD) system. This specification may be applied to Induction or Synchronous AC motor applications.
2. Every VFD system shall consist of all components required to meet the performance, protection, safety, and certification criteria of this specification.
3. The following components must be integrated into the VFD System:

   - Integral input line reactor
   - Active Front End (PWM converter)
   - PWM inverter
   - DC Link with common mode voltage protection
   - Input and output filters if applicable

4. Contractor to include all material and labor necessary to interconnect any VFD system elements, even if shipped separately. All cost to use alternative equipment, including redesign, will be born by the VFD manufacturer. VFD's which require phase shifting transformers will not be acceptable.

1.2 QUALIFICATIONS

A. Manufacturer

1. The manufacturer shall have a minimum of 10 years experience in the manufacturer of medium voltage variable frequency drives for use in similar applications at the specified voltage and power ratings. A user list, complete with contact names and telephone numbers, shall be furnished upon request.
   a. These Specifications are based on products manufactured by Allen Bradley. Other acceptable manufacturers are Benshaw and Eaton.

B. Support
1. The manufacturer shall maintain factory trained and authorized service facilities within 100 miles of the project and shall have a demonstrated record of service for at least the previous ten years owned and operated by the VFD drive manufacturer.
2. Support personnel are to be direct employees of the manufacturer.
3. The manufacturer shall provide all required start-up and training services.

C. Certification
1. The VFD shall be factory pre-wired, assembled and tested as a complete package by the VFD supplier. Customer specific drive, motor, and application data shall be pre-loaded into the operator interface and tested prior to shipment.
2. All inspection and testing procedures shall be developed and controlled under the guidelines of the Supplier's quality system. This system must be registered to ISO 9001 and regularly reviewed and audited by a third party registrar.
3. All incoming material shall be inspected and/or tested for conformance to quality assurance specifications.
4. All sub-assemblies shall be inspected and/or tested for conformance to Supplier's engineering and quality assurance specifications.
5. All printed circuit boards with active components shall be burned-in per the manufacturer's standards.
6. Third party manufacturers and brand labeling shall not be allowed.

1.3 REFERENCES

A. Variable Frequency Drive
1. Canadian Standards Association (CSA) "Industrial Control Equipment C22.2 No. 14"
2. American National Standards Institute (ANSI) "Instrument Transformers C57.13"
3. Institute of Electrical & Electronic Engineers (IEEE)
4. Electrical & Electronic Manufacturers Assoc. of Canada (EEMAC)
5. Guide for Harmonic Control and Reactive Compensation of Static Power Converters (IEEE 519-1992)
6. National Electrical Manufacturers Association (NEMA) "Medium Voltage Controllers Rated 1501 to 7200V AC ICS 3-2 (formerly ICS 2-324)"
7. Underwriters Laboratories, Inc. (UL) (High Voltage Industrial Control Equipment 347)
8. UL 347A Medium Voltage Power Conversion Equipment Preliminary Standard

9. International Electrotechnical Commission (IEC) 61800-5 AC Drives Standard
10. European Directives for Safety and EMC
11. National Electrical Code (NEC)
12. Occupational Safety & Health Act (OSHA)

1.4 ENVIRONMENTAL REQUIREMENTS

A. Confirm to specified service conditions during and after installation of products

B. Maintain area free of dirt and dust during and after installation of products

1.5 PRE-MANUFACTURE SUBMITTALS

A. Refer to Division 1 for submittal procedures

B. Shop Drawings
1. Elevation drawings showing dimensional information
2. Structure Descriptions showing
   a. Enclosure ratings
   b. Fault ratings
   c. Other information as required for approval
3. Conduit locations
4. Unit Descriptions including amperage ratings, frame sizes, trip settings, pilot devices, etc.
5. Nameplate Information
6. Schematic wiring diagrams

C. Product Data
1. Publications on variable frequency drive
2. Data Sheets and Publications on all major components
   a. Contactors
   b. Circuit Breaker and Fuse information including time current characteristics
   c. Control Power Transformers
   d. Pilot devices
   e. Relays
   f. Operator Interface

D. Spares
1. Recommend spare parts list and list prices shall be supplied.
2. Critical Spares - Spare parts that are identified as being associated with long lead times and/or are critical to the unit's operation. These spares should be held in reserve by the Purchaser to limit unforeseen downtime.

3. Maintenance Spares - Spare parts that are identified as being required to regularly perform scheduled maintenance on their equipment. These spares include, but are not limited to, consumable spares that are required to be exchanged during scheduled maintenance periods.

E. Specification Response
   1. Detailed response to this specification showing where in the literature and drawings each requirement is satisfied.
   2. All clarifications and exceptions must be clearly identified.

F. Testing and Test Reports
   1. Testing shall be per manufacturer's standard
   2. A copy of the test reports shall be provided as part of the Closeout documentation

1.6 CLOSEOUT SUBMITTALS

A. Refer to Division 1 for procedure on submittal of closeout documentation

B. Contractor shall provide certification that the variable frequency drive has been installed in accordance with the manufacturer's instructions.

C. The contractor shall provide certification that the Contractor has properly adjusted any timing devices required in the starting circuitry.

D. Final Drawings. The manufacturer shall provide final drawings reflecting the "As-Shipped" status of the motor control center. The contractor shall be responsible for making any changes to the "As-Shipped" drawings from the manufacturer to reflect any field modifications.

E. Maintenance Data
   1. Variable frequency drive installation instructions and User Manual
   2. Installation / Operation instructions for major components such as circuit breakers, contactors, isolation transformers, etc.
   3. Drive Parameter Listing
   4. Field Service report from drive start-up service
   5. Variable Frequency spare parts listing and pricing
   6. Include name and phone number for a local distributor for the spare parts.

1.7 DELIVERY, STORAGE AND HANDLING

A. Contractor shall coordinate the shipping of equipment with the manufacturer.

B. Contractor shall store the equipment indoors in a clean and dry space.

C. The contractor shall protect the units from dirt, water, construction debris and traffic.

D. During storage the contractor shall connect internal space heaters (if specified) with temporary power.

1.8 FIELD MEASUREMENTS

A. The Contractor shall verify all field measurements prior to the fabrication of the variable frequency drives.

1.9 SPARE MATERIALS

A. The following spare parts shall be furnished for each size drive:
   1. Three of each type power and control fuse
   2. Two power modules (SGCT) or 20%, whichever is greater
   3. Two spare LEDs of each type used
   4. Two spare control relays of each type used
   5. Two sets of all replacement air filters
   6. One hoisting mechanism for removal and replacement of power cells, if required
   7. One set of all control printed circuit boards
   8. Furnish all cables required for connection to the drives with a laptop, and all software necessary for configuration and programming.

1.10 WARRANTY

A. The manufacturer shall provide their standard parts warranty for a minimum of one year from the date of project Substantial Completion.

B. The manufacturer shall confirm this warranty as part of the submittal.

PART 2 PRODUCTS

2.1 RATINGS

A. Voltage
   1. The VFD shall accept nominal plant power of 2400V at 60Hz
   2. The supply input voltage tolerance shall be ± 10% of nominal line voltage.

B. Displacement power factor

1. The VFD shall be capable of maintaining a minimum true power factor (Displacement P.F. X Distortion P.F.) of .98 from 60-100% load.
2. If the VFD vendor cannot meet the true power factor requirement, then a power factor correction unit shall be quoted as an option.
3. The true power factor that can be met (with and without power factor correction unit) shall be stated clearly in the proposal.

C. Efficiency
1. VFD system efficiency shall be a minimum of 96% at 100% speed & 100% load. System efficiency shall include VFD, input transformer or line reactor, harmonic filter (if applicable) power factor correction unit (if applicable), and output filter (if applicable). (Assuming a minimum motor PF of 0.86)
2. Control power supplies, control circuits, cooling fans or pumps, shall be included in all loss calculations.

D. Environmental Ratings
1. Storage ambient temperature range: -40 degrees C to 70 degrees C.
2. Operating A. ambient temperature range: 0 degrees C to 40 degrees C without derating.
3. The relative humidity range is 0% to 95% non-condensing.
4. Operating elevation: up to 1000 Meters (3,300ft) without derating.

E. Audible Noise Level
1. The maximum audible noise from the variable frequency drive shall comply with OSHA standard 3074, Hearing Conservation, which limits noise level to 85 dB(A).
2. The variable frequency drive shall comply with the OSHA standard at a distance of one meter from the front of the equipment (with doors closed at any speed or load condition).
3. Variable frequency drives with audible noise in excess of this limit must be provided with sufficient noise abatement treatment to reduce the sound pressure level below 85dB(A).

F. Motor Compatibility
1. The variable frequency drive shall be capable of operating a standard AC squirrel cage induction motor (standard AC synchronous motor, standard AC wound rotor induction motor) of equivalent power and speed rating over the speed range specified. Drives which require motors with higher insulation values will not be acceptable.
2. The variable frequency drive shall provide near sinusoidal voltage and current waveforms to the motor at all speeds and loads. Output current THD shall be less than 5%. Standard induction or synchronous motors shall not require de-rating or upgraded turn-to-turn insulation and shall not require additional service factor.

3. The motor insulation system shall not be compromised thermally or due to dv/dt stress. Dv/dt at the motor terminals (line-to-line) shall be limited to 10 volts per microsecond. If dv/dt at the motor terminals (line-to-line) exceeds 10 volts per microsecond, the vendor must state the actual value in the attached data sheets and include steps taken to guarantee the long term life of the motor insulation system.
4. The variable frequency drive shall provide stable operation of the motor without compromising the motor insulation system, with motor cable distances that exceed 500ft. The vendor shall clearly state the limitations in motor cable distance with the proposal. If an output filter is required to mitigate reflected waves, or to meet any special requirements of the application, it must be integral to the VFD controller.
5. If output filters are used in the variable frequency drive, a selective harmonic elimination (SHE) switching technique must be available to eliminate a potential harmonic resonance in the operating speed range.
6. Variable frequency drive induced torque pulsations to the output shaft of the mechanical system shall be less than 1% to minimize the possibility of exciting a resonance.

G. Sizing
1. Loads shall be as shown on the drawings.

H. Definitions
1. The Drive Unit shall refer to the actual drive that will be mounted within the specified enclosure.
2. The Drive System shall refer to the drive unit and all items specified under Drive System Options.

2.2 DRIVE UNIT DESIGN

A. Hardware
1. The VFD shall be designed for a minimum availability of 99.9%.
2. The VFD shall be designed for a Mean Time Between Failures (MTBF) of 100,000 hours.
3. In order to optimize reliability and minimize complexity, inverter power switch component count shall be minimized by utilizing 6500V peak inverse voltage (PIV) rated devices, with double sided cooling and integral gate driver card. Preference will be given to designs exhibiting the lowest overall power component count.
4. The VFD shall have a control power monitoring system that monitors all power supply voltages and signals.
5. Fiber optic interface boards shall be used to provide gating and diagnostic feedback signals for power semiconductor devices. The diagnostic feedback system shall allow constant control of the

device as well as constant monitoring of device health and temperature feedback.

6. Field programmable gate arrays (FPGA) shall be utilized on drive control boards to provide high speed handling of diagnostics and fault handling routines. High speed digital control systems shall continuously monitor all hardware and software faults including sensing of all power circuit voltage and currents as well as any internal equipment faults.
7. Power switch device diagnostics shall detect and protect against device short, over or under gate voltage, loss of gating, loss of diagnostic feedback, heat sink temperature feedback as well as overload monitoring and protection.
8. Failed power switch components (SGCTs) shall be replaceable without removal of the entire power module. Special tools or force measuring transducers shall not be required. Failed power switch components shall be replaceable in less than 5 minutes. Power cells shall weigh less than 50lbs.
9. VFD components shall not require maintenance or replacement during the first 5 years of operation.

B. Control Logic

1. The VFD shall produce a variable voltage and variable frequency output to provide continuous operation over the application speed range.
2. The VFD shall be capable of operating with the output short circuited at full current.
3. The drive system shall provide controlled speed over the range specified. Speed accuracy within this range, expressed as a percent of top speed, shall be within 0.1% of base speed without encoder or pulse tachometer feedback (0.01% with encoder or pulse tachometer feedback).
4. The VFD shall have a "normal duty" rating of 100% continuous current with a short-time duty rating of 110% overload for one minute, once every 10 minutes (suitable for variable torque loads).
5. The variable frequency drive shall be capable of 100% breakaway torque without tachometer feedback.
6. For high inertia loads, a preference shall be given to variable frequency drives capable of regenerative motor braking.

2.3 DRIVE UNIT FEATURES

A. Control Mode

1. The variable frequency drive shall utilize sensorless direct vector control or full vector control, with pulse tachometer feedback, for optimum performance.

B. Auto Tuning

1. The variable frequency drive shall have a programmable auto tuning function.
2. The function shall be capable of being disabled.
3. The function shall be programmable for the following tuning options.
    a. Communtation inductance
    b. DC link time constant
    c. Motor stator resistance
    d. Motor leakage inductance
    e. Flux regulator
    f. Total Inertia

C. Starting Mode
1. The variable frequency drive shall offer two starting modes.
2. The S-Curve profile shall consist of both nonlinear and linear portions.
    a. A parameter shall exist that specifies the duration that the drive is ramping in the non-linear portion.
    b. A parameter shall define the total time to accelerate to rated speed in S-Curve.
3. The Ramp Mode shall be programmable with four ramp speed break points
    a. The Ramp Mode shall have programmable acceleration and deceleration times.
    b. The Ramp Mode shall have a parameter for Ramp Start Delay that specifies the time the speed reference remains at zero after the drive is started.

D. Stopping Mode
1. The variable frequency drive shall have three stop modes.
2. The Ramp Mode shall be programmable with four deceleration times.
3. In the Coast Mode, a programmable parameter shall be set to specify the speed at which the drive shuts off and coasts when stopping.
4. Regen Mode

E. Auto-Restart Capability
1. The VFD shall be capable of automatically restarting in the event of a momentary loss of power.
2. An automatic restart delay parameter shall be available in the drive with an adjustment range of 0 -10 seconds.

F. Flying Re-Start
1. The VFD shall be capable of restarting and taking control of a motor attached to a spinning load in the forward or reverse direction.

G. Preset Speeds
   1. The variable frequency drive shall have three (3) preset speeds.
   2. The preset speeds shall be programmable between 0.5 and 75.0 Hz.

H. Skip Speeds
   1. The variable frequency drive shall have three (3) skip speeds.
   2. The skip speeds shall be programmable between 1.0 and 75.0 Hz.
   3. The skip speeds shall have a programmable band width between 0.0 and 5.0 Hz.

I. Ride Through
   1. The VFD shall be capable of riding through a loss of power of 5 cycles.
   2. If specified, a UPS shall be supplied inside the VFD controller for an extended ride through of up to 2 minutes.
   3. The VFD system shall be capable of operating with a 30% voltage sag on the input power line. The motor shall not be allowed to reach a pull out condition.

J. Load Loss Detection
   1. The drive shall have a parameter to specify the response of the drive to a loss of load condition.
   2. The parameter shall have the following configuration options: disabled, warning or fault.

K. Digital I/O
   1. Sixteen (16) isolated digital inputs shall be available as standard on the drive.
   2. Sixteen (16) isolated digital outputs shall be available as standard on the drive.
   3. Digital I/O shall be rated 12V to 260V AC or DC.

L. Fault Configuration
   1. The variable frequency drive shall have fault classes that define the following.
      a. Class of drive input protection
      b. Class of rectifier magnetic protection
      c. Class of dc link protection
      d. Class of motor protection
      e. Class of isolation transformer protection
      f. Auxiliary trip class
      g. External fault class

   2. Each fault class shall have the following configurations.
      a. Disable the fault input

b. The drive will shut down immediately
c. The drive will perform a controlled shutdown
d. The drive will not shutdown but a warning will be displayed

3. The variable frequency drive shall have fault and warning masks.

M. Protection Features
1. Fault information shall be accessible through the Human Interface
2. The variable frequency drive shall have the following minimum line side protective features.
a. Line current unbalance trip with programmable delay
b. Line overcurrent trip with programmable delay
c. Line overload warning and trip with programmable delay
d. Line overvoltage trip with programmable delay
e. Line undervoltage trip with programmable delay
f. Line voltage unbalance trip with programmable delay
g. Ground fault overvoltage trip with programmable delay
h. Ground Fault overcurrent trip with programmable delay

3. The variable frequency drive shall have the following minimum system level protective features.
a. DC Overcurrent trip with programmable delay
b. DC overvoltage trip with programmable delay
c. Rectifier heatsink temperature warning and trip
d. Cabinet temperature warning and trip
e. Inverter heatsink temperature warning and trip
f. Control Power warning and fault
g. Adapter (communication port) loss warning and fault
h. XIO adapter loss

4. The variable frequency drive shall have the following minimum load side protective features.
a. Ground fault overvoltage trip with programmable delay
b. Ground fault overcurrent trip with programmable delay
c. Machine side dc link overvoltage trip with programmable delay
d. Motor overcurrent trip with programmable delay
e. Motor overload warning and trip with programmable delay
f. Motor overvoltage trip with programmable delay
g. Motor stall delay
h. Motor overspeed trip with programmable delay
i. Motor flux unbalance trip with programmable delay
j. Motor current unbalance trip with programmable delay
k. Load loss level, speed and programmable delay

N. Metering

1. The variable frequency drive shall display metered parameters through the operator interface.
2. The variable frequency drive shall meter the following.
   a. Root Mean Square value of the motor current
   b. Root Mean Square value of the motor terminal voltage
   c. Motor output power in kilowatts
   d. Motor speed in revolutions per minute

3. The metered values shall be capable of being assigned to an analog output to drive an optional output meter.

2.4 DRIVE SYSTEM CONSTRUCTION

A. Structure (Air Cooled VFD's)
   1. Enclosure
      a. Air-cooled VFD enclosures shall be NEMA 1 (IP21). Door vents shall consist of louver-panel assemblies that can be removed from the front in order to replace air filters. Safety screens shall be located behind each louver panel. Cabinets and doors shall be fabricated using minimum 12 gauge (2.64 mm thick) steel for sturdy construction. All doors shall be gasketed to provide environmental protection and secure fits.
      b. Door latches shall be heavy-duty ¼-turn type units which are operated with an Allen wrench. The converter cabinet door and cabling cabinet door shall be interlocked with up-stream isolators or breakers with a key lock. Interlocking shall be fully coordinated to prevent access to all medium voltage compartments.
      c. The VFD shall be designed for front access to allow for installation with no rear access. Equipment that requires rear or side access shall not be accepted.

   2. Structure Finish
      a. All variable frequency drive exterior metal parts (except for low voltage panel, external isolating switch handle assembly, lifting angles, lifting brackets and low voltage wireway cover) shall be painted with hybrid epoxy powder paint per manufacturer's standard color.
      b. Low voltage panel, external isolating switch handle assembly, lifting angles, lifting brackets and low voltage wireway cover shall be painted with hybrid epoxy powder paint using manufacturer's standard color.
      c. All metal back plates in the power cell and low voltage compartments shall be painted high gloss white for high visibility.

d. Touch-up spray can(s), matching the enclosure color, shall be supplied.
e. Painting shall be done on a continuous paint line through air-atomized electrostatic spray. All parts shall be painted before assembly.
f. The preparation shall be Alkaline wash/rinse; iron phosphate rinse; iron-chrome sealer rinse; re-circulated de-ionized water rinse and virgin de-ionized water rinse
g. Total paint thickness – 0.002" (0.051 mm) minimum
h. Baking process shall be by Natural gas oven at 179°C (355°F) minimum.
i. All unpainted steel parts shall be plated with a zinc plate/bronze chromate process for corrosion resistance.

3. Cooling System (air cooled system)
1. The VFD system shall be air-cooled unless otherwise specified.
2. Air-cooled VFDs shall be provided with a single, mixed flow cooling fan, mounted integral to the VFD enclosure. The VFD shall include air flow pressure switches and temperature detectors to monitor proper operation of the air cooling system. If a fan fails, the system must generate alarm indication of the fan failure. Vane type air flow switches are not acceptable.

G. Cabling
a. The VFD shall contain a power cable termination assembly designed for easy termination and access to line and load cables. The termination assembly cabinet shall allow for top and bottom entry and exit of line and load cables.
b. A low voltage wire way shall be provided at the top front of the VFD and shall be available with a removable cover.
c. All power and control terminations and termination strips shall be identified in accordance with all schematics and wiring diagrams.
d. Low voltage control wire shall be TEW tinned, 600 volt AC rated.

H. Harmonic Mitigation Techniques
1. VFDs shall comply with the latest edition of IEEE 519 Harmonic Guidelines.
2. Preference shall be given to drive systems that meet IEEE 519 harmonic guidelines with the lowest possible design complexity. The VFD supplier shall detail the number of main power components supplied in the VFD in the vendor's proposal.
3. The following VFD rectifier solutions are acceptable:
a. PWM rectifier (Active Front End)

I. Auxiliary Relays
   1. Provide relays for Drive Warning, Drive Fault, Drive Run and Drive Ready.
   2. Provide (2) additional relays to be wired per custom requirements.
   3. The relays shall consist of 2 form C contacts, 2N.O. & 2N.C.The relay contacts shall be rated for 115V AC/30V DC, 5.0 Amp resistive, 5.0 Amp inductive.

J. Communications
   1. The VFD shall be provided with Ethernet IP digital communication capability.

K. Isolated Analog Input and Output
   1. The analog interfaces shall be isolated.
   2. The analog signal interfaces shall be configurable for:
      a. Speed reference input (4-20 mA input signal).
      b. Speed output (4-20 mA output signal).

L. Pilot Devices
   1. Pilot devices shall be NEMA Type 4/4X/13 and shall be mounted on the drive system enclosure door.
   2. Provide the operator interface devices, including but not limited to hand-off-auto and start-stop pushbuttons, as shown on the Contract Drawings.
   3. Provide pilot lights, mounted on the enclosure door, for indication of Ready, Run, Fault and Warning. Pilot lights shall be transformer type.
   4. Provide a NEMA Type 1/4/12, single turn speed pot mounted on the drive system enclosure door.

M. Motor Run Time Meter
   1. Provide a digital, non-resettable, door-mounted elapsed time meter.
   2. The meter shall be electrically interlocked with the Drive Run relay and Bypass contactor (if required) to indicate actual motor operating hours.

N. Operator Interface Module
   1. The VFD shall have a user-friendly operator interface terminal.
   2. The interface terminal shall have the following minimum features.
      a. 10 Inch color touch screen with Windows CE 6.0 Operating System
      b. Built in .pdf viewer that allows VFD specific drawings and manuals to be displayed on the interface screen
      c. Option to be mounted locally at the VFD panel or remotely via EtherNet communication link

d. User configurable analog metering for motor speed, load, torque, and voltage
e. On screen operator interface devices for start, stop, E-Stop and speed control
f. Elapsed time indication
g. Extensive diagnostic functions that provide separate fault and warning queues in non-volatile memory that retain information under all conditions
h. Ability to perform diagnostic and troubleshooting functions from a user supplied laptop computer
i. On-line help that provides enhanced fault text messages
j. Trend buffers for at least 8 variables that allow one-shot or multi-shot trending
k. Multi-level (minimum of four levels) password access to ensure that only qualified personnel have access to critical parameters but still allow easy access to other levels of personnel
l. Extended use of plain language messages to eliminate need to look up error codes or decipher the meaning of error messages
m. Start-up wizard, including auto tuning, that is interactive and user-friendly

P. Motor Protection Options
1. Furnish and install a motor protective relay as specified in Section 26 24 19.

2.5 AC LINE REACTORS

A. An AC line reactor shall be supplied as part of the VFD package. The VFD system with line reactor shall include common mode voltage protection for the motor. (special motor insulation shall not be required).

B. Multi-secondary, phase shifting transformers are not acceptable.

C. Line reactors shall be integral to the VFD line-up.

D. The line reactor K-factor shall be designed for rectifier service (AFE rectifier).

E. The line reactor shall be convection cooled with Class H insulation.

F. The line reactor shall include thermal protection.

2.6 INPUT CONTACTOR WITH ISOLATION UNITS

A. The medium voltage input contactor and isolation unit shall be provided with the following features:

1. Fixed mounted vacuum contactor
2. The 400A units shall include one three-pole, gang-operated, non-load break isolating switch with one single external operating handle. Isolation switch is to be mechanically interlocked with the contactor and power cell doors.
3. Three R-rated current-limiting power fuses.
4. Bar type current transformers.
5. Low voltage control panel complete with pilot control relays; control circuit fusing; DC economizing circuits; "Normal-Off-Test" circuit; receptacle for remote test supply; set of control circuit terminal blocks.
6. Low voltage and power cell doors with viewing windows in both power cell doors to view the position of the isolating switches.

EXECUTION

3.1 TESTING AND INSPECTION

A. Standard Testing

1. The following tests shall be carried out in accordance with applicable requirements and/or specifications of Canadian Standards Association (CSA), Underwriters Laboratories (cULus), National Electrical Manufacturers Association (NEMA), European Standard (EN), and International Electrotechnical Commission (IEC).
2. Functional checks shall be performed wherever possible; otherwise, inspection and continuity checks shall be made.
3. A "HI-POT" dielectric withstand test shall be performed on all buswork and cables from phase-to-phase and phase-to-ground (except solid-state components, low voltage controls and instrument transformers). The voltage level used for this test depends on the product's nominal AC voltage.
4. Component devices shall be functionally operated in circuits as shown on electrical diagrams or as called for by specific test instructions.
5. Instruments, meters, protective devices and associated controls shall be functionally tested by applying the specified control signals, current and/or voltages.
6. Medium Voltage Drives shall be inspected for the following:
   a. Control Power Failure Test
   b. Rectifier Gating Checks
   c. Inverter Gating Checks

d. Line Converter Tests
e. Machine Converter Tests
f. Load Tests

7. Cycle Testing
   a. Drives shall be accelerated to the test motor's nominal frequency, under load on a dynamometer.
   b. Drives shall be decelerated to 10 Hz and then accelerated back to test motor's nominal frequency with a ramp time of approximately ten seconds.
   c. This cycle shall be repeated continuously for up to one hour.
8. Load Testing
   a. Drives shall be tested under load at the test motor's nominal frequency
   on a dynamometer. Testing on load banks not acceptable.

B. Physical Inspection
1. The product must meet all applicable engineering and workmanship standards and specifications. All components shall be verified against engineering documentation to be present and correctly installed.
2. All bus and bus connections shall be checked for proper clearance, creepage, phasing, and torque.
3. Warning plates, isolation barriers, and mechanical interlocks must provide sufficient safety/isolation for personnel and equipment.
   a. Warning labels and nameplates must be present and in their specified positions to advise personnel of possible hazards.
   b. Isolation barriers must be in place within the cabinet. Such barriers protect personnel from touching live medium voltage components in an area that otherwise does not have power supplied to it.
   c. Operation of isolation switch handle and door interlocks must be verified. The interlocking prevents the opening of any medium voltage door on a medium voltage cabinet when the isolation switch handle has been moved to the full ON position.

3.2 MANUFACTURE'S FIELD SERVICES

A. The service division of the variable frequency drive manufacturer shall perform all start-up services. The use of third party supplier start-up personnel is not allowed.

B. Start-up of the variable frequency drives shall be coordinated with the start-up of the driven equipment, and other related equipment which may pertain to drive settings. The VFD field service representative shall be

available during the entire start-up procedure to adjust VFD settings as required for the entire system operation.

C. Start-up personnel shall be direct employees of the variable frequency drive manufacturer and shall be degreed engineers.

D. Provide a minimum of 4 days of on-site start-up service for each VFD.

E. At a minimum, the start-up service shall include:
   1. Pre-Installation Meeting
      a. The start-up plan
      b. The start-up schedule
      c. The drive's installation requirements
   2. Pre-Power Check
      a. Inspect the drive's mechanical and electrical devices enclosed
      b. Perform a tug test on all internal connections within the drive and verify wiring.
      c. Verify critical mechanical connections for proper torque requirements.
      d. Verify and adjust mechanical interlocks for permanent location.
      e. Confirm all sectional wiring is connected properly.
      f. Re-verify control wiring from any external control devices.
      g. Set up all drive internal power supplies and thyristor control circuits.
      h. Verify proper phasing from isolation transformer to drive.
      i. Confirm cabling of drive to motor, isolation transformer and line feed.
      j. Megger Motor Resistances.
   3. Drive Power-up and Commissioning
      a. Apply medium voltage to the drive and perform operational checks.
      b. Bump motor and tune drive to the system attributes
      c. Run the drive motor system throughout the operational range to verify proper performance.
   4. Record all measurements
   5. Provide Drive Parameter Listing

3.3 TRAINING

A. Manufacturer to provide on-site instruction as specified in Specification Section 26 05 05.

B. The service engineer shall perform training.

C. The manufacturer shall outline the training session duration and content.

D. The basis of the training shall be the variable frequency drive, the engineered drawings and the user manual.

E. The instruction shall include the operational and maintenance requirements of the variable frequency drive.

F. At a minimum, the training shall:
   1. Review of the engineered drawings identifying the components shown on the drawings.
   2. Review starting / stopping and speed control options for the controller.
   3. Review operation of the Operator Interface for programming and monitoring of the variable frequency drive.
   4. Review cooling system operation.
   5. Review the maintenance requirements of the variable frequency drive.
      a. Board replacement procedures
      b. Power device replacement procedures
      c. Fault analysis and troubleshooting
      d. Preventative maintenance procedures
   6. Review safety concerns with operating the variable frequency drive.

++END OF SECTION++

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SECTION 26 41 00

ELECTRICAL DEMOLITION

PART 1 – GENERAL

1.1 SCOPE OF WORK

A. Furnish all labor, equipment, materials, and supplies necessary for and reasonably incidental to demolition of work hereinafter specified, indicated on drawings, required or intended for completion of the work.

B. Major items included under demolition work include, but are not limited to:
   1. Electrical equipment and connections associated with existing Flocculation/Sedimentation Basins.
   2. Interior electrical, lighting, etc. in the third floor area of the existing Filter Building, as called out on contract drawings.
   3. Electrical equipment and connections located within the existing Tunnel. Majority of equipment will be relocated.

C. Repair those areas damaged under demolition work once new services and systems have been installed.

1.2 SUBMITTALS

A. No submittals are anticipated under this Section.

1.3 JOB CONDITIONS

A. Provide adequate protection to persons and property. Execute work in such a manner as to avoid interference with required operations and use of or passage to and from adjoining buildings and facilities.

B. Demolition work of equipment necessary for the operation of the power and communication systems to be coordinated with the installation of new equipment. The demolition and installation work is to be done as quickly as possible to minimize any burdens on the Owner.

1.4 CONDITION OF EXISTING FACILITIES

A. Contractor shall verify the areas, conditions and features necessary to tie new work into existing construction. This verification shall be done prior to submittal of shop drawings, fabrication or erection, construction or installation. The Contractor shall be responsible for the accurate tie-in of the new work to existing facilities.

PART 2 – PRODUCTS (NOT USED)

PART 3 – EXECUTION

3.1 SCHEDULES

A. Schedule all demolition work as to cause minimal interference with existing facility operations. Refer to Specification Divisions 0 and Division 1 for additional requirements.

B. Obtain prior approval of the Owner at least seven days in advance before starting demolition of any equipment. Under no circumstances will demolition work be approved until new equipment is ready for installation.

3.2 PREPARATION

A. Disconnect or arrange for disconnection of utility service connections to equipment and areas to be demolished before starting demolition.

B. Preserve in operating condition all active utilities transversing the project site. Protect all equipment that remains (electrical and mechanical) during demolition, and repair all damage caused by this work to satisfaction of Engineer.

3.3 APPLICATION

A. Maintain the continuity of the existing branch circuits serving all existing light fixtures, receptacles, or equipment that are to remain, whether indicated or not on the drawings.

B. All existing walls, ceilings, floor slabs, etc., being cut or damaged under this Contract shall be patched back to match existing by General Contractor.

C. At the discretion of the Owner, all existing switchgear, lighting fixtures, receptacles, control equipment and switches being removed shall be disposed of by the Contractor. Refer to 16050 for more details.

D. Remove exposed ground conductor back to source or point of contact with slab. Cut conductor off below slab and abandon with hole being patched back to match existing surface (floor, wall or ceiling). If reusable, simply disconnect ground conductor.

E. Conduits, wire and wood products that are not salvageable shall be disposed of legally.

F. Primary work shall be completed with all facilities kept in service or with short periods of scheduled momentary outages.

G. Holes in slabs or into classified areas to be patched to provide a gas, vapor and watertight barrier.

3.4 STORAGE AND HANDLING

A. The Owner reserves the right to save materials that are a part of the demolition work, and the Contractor shall turn over and store any such materials at the Owner's direction.

B. All materials not turned over to Owner shall become property of Contractor and removed promptly from project site at no additional cost to the Owner. Any permits or fees for disposal shall be the responsibility of the Contractor.

3.5 CLEANUP

A. Burn no materials or debris on premises.

B. Remove from site rubbish and debris found thereon and, except as otherwise specified, materials and debris resulting from work of demolition. Leave site in safe and clean condition.

+ + END OF SECTION + +

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SECTION 26 43 00

SURGE PROTECTION DEVICES

PART 1 - GENERAL

1.1 SCOPE OF WORK

A. Instrumentation Surge Protection Devices
   1. Surge Protection Devices are intended for use on all instrument control loops for power and signal protection on transmitters/receivers, etc., and shall be furnished and installed as specified in Division 40.

B. Secondary Power Arrestors (480, 240, or 240/120 Volts a-c)
   1. Secondary power arrestors shall be furnished and installed on all control equipment supplied as outlined on the Contract Drawings.

C. Surge Protection Devices (480, 240, or 240/120 Voltage)
   1. Surge Protection Devices shall be furnished and installed in all Power Distribution Panels and on all equipment supplied having solid state components as the central control/monitoring device. These shall included, but not be limited to, computer systems, level control systems, and/or variable speed equipment. They shall be shown on the Drawings where required.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Secondary Power Arrestors
   1. "Dale," "General Electric," or equal.

B. Hybrid Surge Protection Devices
   1. "Atlantic Scientific Corporation," "LEA Dynatech," "Current Technology," "Advanced Protection Technologies," or equal.

2.2 EQUIPMENT

A. Secondary Power Arrestors
   1. The arrestor shall be hermetically sealed with pre-ionized spark gap. The unit shall be capable of repeated overvoltages without significant change in breakdown level or insulation resistance. The arrestor shall be capable of mounting in any position and shall be capable of mounting through a box knockout with standard locknuts, and shall be weatherproof.
   2. Capacitance shall be less than 50 picofarads, and insulation resistance shall be at least 100 megohms. Maximum arc-over with 10 KV/micro second

rise time pulse applied shall be 1,500 volts. The arrestor shall be capable of withstanding repeated application of 10 kiloampere current surges and extinguish power-follow current in 2 cycle or less. Maximum voltage between terminals shall be 2,500 volts when conducting 10 kiloampere current surges.

3. Operating temperature range shall be -40 degrees Celsius to +75 degrees Celsius.

B. Surge Protection Devices

1. The nominal operating voltage and configuration shall be as indicated on the contract drawings.
2. The maximum continuous operating voltage (MCOV) of all suppression components utilized in the unit shall not be less than 115% of the facility's nominal operating voltage.
3. SPD shall be UL labeled with 20kA Inominal (I-n) for compliance to UL 96A Lightning Protection Master Label and NFPA 780.
4. The system shall provide a noise filtering system capable of attenuating noise levels produced by electromagnetic interference and radio frequency interference. The system's filtering characteristics shall be expressed in decibels (dB) of attenuation per NEMA LS1 publication. The noise filtering system shall also be UL 1283 listed as an Electromagnetic Interference Filter.
5. The SPD unit, in the configuration required by this project (integral disconnect or no integral disconnect), shall have a minimum interrupt rating of 200kAIC.
6. NEMA LS-1-1992 (R2000) Clamping Voltage Data. The unit's clamping voltages shall be in compliance with test and evaluation procedures outlined in NEMA LS-1-1992 (R2000), paragraphs 2.2.10 and 3.10.
7. The unit shall be UL 1449 3rd Edition Listed. The UL 1449 2nd Edition suppressed voltage ratings (SVR) for the unit including integral disconnect shall be equal to or below the following values:

UL 1449 3rd Edition Suppressed Voltage Ratings (SVR)				
System Voltage	Mode of Protection			
	L-N	L-G	N-G	L-L
120/240	700	700	900	1000
120/208	700	700	500	700
277/480	1000	1200	1200	1800

8. Tested Single Pulse Surge Current Capacity.
   a. The maximum single-pulse surge current capacity per mode shall be verified through testing at an independent third party testing facility and shall be conducted per NEMA LS-1-1992 (R2000), paragraphs 2.2.9 and 3.9. The unit shall be tested in all modes at rated surge currents and all tested modes shall be from the same test sample. This test shall include all components of the system, including disconnects (if applicable), fusing, and monitoring as a completed assembly.

Individual component testing, module testing only, or subsystem testing of the unit for compliance with this section will not be acceptable. Testing that causes damage to the device, fuse operation, or voltage clamping performance degradation by more than 10% is not acceptable.

9. Minimum Repetitive Surge Current Capacity.
   a. Per IEEE C62.41-1991 and C62.45-2002, the product shall be repetitive surge current capacity tested in every mode utilizing the following:
      1) 1.2 x 50 μsec, 20 KV open circuit voltage, 8 x 20 μsec, 10 kA short circuit current Category C3 combo-wave at one minute intervals without suffering either performance degradation or more than +10% deviation of clamping voltage at the specified surge current.
      2) The device shall be capable of surviving a minimum of 11,000 impulses without failure or performance degradation.
10. Service Entrance Suppressors
   a. Equipment shall Equipment shall be a multi-stage parallel protector rated for 480Y/277. See online diagram and panelboard schedule to confirm voltages. The equipment's minimum surge current capacity shall be 200kA per mode (L-N, L-G, L-L and N-G).
   b. The system protection modules shall contain a technology that utilizes a symmetrical array of balanced metal oxide varistors (MOV). Each MOV will be individually coordinated to pass UL 1449.
   c. All primary transient paths shall utilize copper wire, aluminum bus bar and lugs of equivalent capacity to provide equal impedance interconnection between phases. No plug-in module or components shall be used in surge carrying paths.
   d. Each protection module shall have a visual indicator that signifies that the protection circuitry is on line. The unit shall not be taken off line to verify integrity of system. Redundant status indicators shall be mounted on the front of the door that monitors the system protection circuitry (or be visible through the enclosure front).
   e. The system shall be modular with field replaceable modules. Modular units shall contain a minimum of one module per phase.
   f. Equipment shall utilize a NEMA 1 enclosure.
11. Panelboard Suppressors & Auxiliary Panel Suppressors
   a. Device shall meet all specification requirements for service entrance suppressors except as follows:
      1) . Equipment shall be a multi-stage parallel protector rated for 480Y/277 or 208Y/120. See online diagram and panelboard schedule to confirm voltages. The equipment's minimum surge current capacity shall be 100kA per mode (L-N, L-G, L-L and N-G).
      2) . The system protection shall contain a technology that utilizes a symmetrical array of balanced metal oxide varistors (MOV).

Each MOV will be individually coordinated to pass UL 1449. The unit shall be non-modular type.

3) . Equipment shall utilize a NEMA 1 enclosure.

12. Accessories
    a. Device Monitoring
        1) . As a minimum, device monitoring shall include: Audible alarm with alarm disable switch, surge counter, and two sets of Form C contacts for remote monitoring.
    b. Integral Disconnect Switch
        1) The unit shall include an integral safety interlocked disconnect located in the unit enclosure with an externally mounted manual operator. If fuses are included with this switch, the fusing shall not effectively lower the rating of the SPD unit.

PART 3 - EXECUTION

3.1 INSTALLATION/APPLICATION/ERECTION

A. Where the SPD unit is not specified with an integral safety/disconnect switch an appropriately sized disconnect switch or thermal magnetic breaker shall be installed before and in-line with the SPD. It shall be capable of electrically isolating the SPD from the electrical service for repair without interrupting service to the building. If a safety/disconnect switch is utilized the switch shall be rated for 600VAC. If fuses are included with this switch, the fusing shall not effectively lower the rating of the SPD unit and shall have a minimum interrupt rating of 200kAIC. Connection means utilizing breakers shall be sized at 60A/3P and 30A/3P respectively for service entrance/switchboard/switchgear and branch panelboard units unless otherwise recommended by manufacturer.

B. The specified SPD system shall be installed with #6 AWG minimum copper conductors tapped from the electrical power distribution system. The conductors are to be as short and straight as practically possible and shall not exceed 5 electrical feet from the power conductor(s) it is protecting for service entrance/switchboard/switchgear units and 1.5 electrical feet for branch panelboard units, and shall avoid any unnecessary or sharp bends. The input conductors are to be twisted together to reduce the SPD system inductance.

C. The SPD shall be installed following the SPD manufacturer's recommended practices and in compliance with these specifications and all applicable codes.

3.2 WARRANTY

A. Manufacturer shall provide a full 5-year limited warranty against failure or workmanship defects when installed in compliance to the manufacturer's written installation instructions, UL listing requirements and the National Electrical Code.

++ END OF SECTION ++

SECTION 26 50 00

LIGHTING

PART 1 - GENERAL

1.1 SCOPE OF WORK

A. The specific characteristics of the light fixtures to be furnished and installed shall be as detailed in the Light Fixture Schedule on the Contract Drawings. Should a fixture of a different type or manufacturer than that specified be submitted for the Engineer's review, it will be compared to that specified on: construction, dimensions, and photometrics. Failure to compare equally to what was specified will be grounds for rejection.

B. The Contractor shall be prepared to submit sample equipment for appraisal when requested by the Engineer, and shall assume all transportation costs involved in the shipment and return of samples. All sample fixtures submitted shall be provided with lamps and shall be wired with cord and plug, to facilitate lighting for appraisal.

PART 2 - PRODUCTS

2.1 LUMINAIRES

A. All fixtures shall be delivered complete with suspension and mounting accessories, ballasts, diffusers, reflectors, etc., all wired and assembled. All accessory wiring shall be furnished and installed as shown on the Contract Drawings.

B. All steel supports required for luminaires in addition to that furnished under the general building construction shall be furnished and installed by the Contractor.

C. When fixtures are noted to be installed flush, they shall be complete with the proper accessories for installing in the particular ceiling involved. All flush mounted fixtures shall be supported from the structure and shall not be dependent on the hung ceilings for their support.

D. All outside luminaires shall be a type that will prevent insect accumulation inside the luminaire.

E. Exterior luminaires shall be weatherproof and rustproof.

F. Luminaire wire shall be fixture type of non-asbestos construction.

2.2 ENCLOSED AND GASKETED LED LUMINARE

A. The fixture shall be constructed of one-piece fiberglass housing with continuous poured-in-place, closed-cell gasket, tool-less ballast and wiring access.

B. The fixture shall house injection-molded, impact-resistant clear acrylic diffuser with frosted ends and side lineal prisms securely tethered to fixture for ease of maintenance.

C. The fixture shall house high-efficiency LEDs mounted to core circuit board.

D. The fixture shall include integral surge protection tested in accordance with IEEE/ANSI C62.41.2 to Category C Low.

E. The fixture shall include a temperature sensing component that limits the temperature of the LEDs in case of excessive ambient temperatures or mis-application.

F. The fixture expected service life shall be minimum of 60,000 hours at 80% lumen maintenance.

G. Fixture shall have an option of ceiling or suspend mounted.

H. Surface conduit entry provisions shall have watertight plugs.

I. Mounting pendants and all associated hardware shall be provided.

J. The fixture shall be suitable for wet location and NEMA 4X rated. IP65, IP66 and IP67 rated and certified to meet NSF Splash Zone 2. 1500 PSI hose-down.

K. The LED driver(s) shall operate at 120VAC.

PART 3 - EXECUTION

3.1 INSTALLATION/APPLICATION/ERECTION

A. General
1. The Contractor shall furnish all light fixtures, lighting equipment, components, hangers, etc., as shown on the Contract Drawings and shall install them at the locations shown on the Contract Drawings.
2. All fixture wiring shall be in conformance with the latest revision of the NEC and UL standards.

3. Locations of fixtures shall be coordinated with Engineer's reflected ceiling plans where they exist. Any conflicts between electrical plans and Engineer's reflected ceiling plans, the reflected plans shall override.

B. Luminaires
1. Fixtures shall be rigidly mounted against the surface of the ceiling unless otherwise noted on the Contract Drawings. Conduit runs to and between fixtures shall be rigid metallic type. Use of flexible conduit for connection to fixtures is prohibited, except where concealed above a suspended ceiling.
2. All ferrous metal surfaces of fixtures and plaster frames shall be treated and given rust inhibiting and finish coat adherence properties before final enamel coats are applied. Finish enamel coat shall be baked on at approximately 320° F.
3. Similar fixtures in each room or area shall be installed with bottom of fixtures at same elevation, unless otherwise noted.
4. Minimum wire size shall be AWG No. 10 for runs over 75 feet.
5. Outlets shall be as specified herein and shall be suitable for the installation conditions encountered.
6. Flexible fixture hangers shall be used for all pendant-mounted fixtures.
7. Conduit run in areas with hung ceilings shall be installed in the space above the hung ceiling as close to the structure as possible. Conduits and junction boxes shall be supported from the structure.
8. No light fixtures shall be hung or installed until after painting is completed, however, temporary lighting shall be provided by the Contractor. Fixtures in suspended ceilings shall be fastened to the main tees of the ceiling grid for seismic considerations, although they shall be supported from the building structure.
9. All fixtures shall be left in a clean condition, free of dirt and defects, before acceptance by the Engineer.

++ END OF SECTION ++

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SECTION 40 05 05

EXPOSED PIPING INSTALLATION

PART 1 - GENERAL

1.1 DESCRIPTION

A. Scope:
   1. CONTRACTOR shall provide all labor, materials, equipment and incidentals as shown, specified, and required to install and test all exposed piping, fittings, and specials. The Work includes the following:
      a. All types and sizes of exposed piping, except where exposed piping installations are specified under other Sections or other contracts.
      b. Unless otherwise shown or specified, this Section includes all piping beginning at the outside face of structures or structure foundations and extending into the structure. Piping embedded in concrete within a structure or foundation shall be considered as exposed and is included herein. Piping that is permanently or intermittently submerged, or installed in sub-aqueous environments, is considered as exposed and is included in this Section.
      c. Work on or affecting existing exposed piping.
      d. Installation of all jointing and gasket materials, specials, flexible couplings, mechanical couplings, harnessed and flanged adapters, sleeves, tie rods, and all Work required for a complete exposed piping installation.
      e. Supports, restraints, and other anchors.
      f. Field quality control, including testing.
      g. Cleaning and disinfecting.
      h. Incorporation of valves, meters, and special items shown or specified into the piping systems per the Contract Documents and as required

B. Coordination:
   1. Review installation procedures under this and other Sections and coordinate installation of items that must be installed with or before exposed piping Work.
   2. Coordinate with appropriate piping Sections of Division 40, Mechanical.

C. Related Sections:
   1. Section 09 91 00, Painting.
   2. Section 10 14 00, Signage.
   3. Section 40 05 07, Pipe Hangers and Supports.
   6. Section 40 05 96, Vibration, Seismic, and Wind Controls.

1.2 REFERENCES

A. Standards referenced in this Section are:
   1. ANSI B16.1, Cast Iron Pipe Flanges and Flanged Fittings
   2. ASME Boiler and Pressure Vessel Code.
   3. ASME B31.3, Process Piping.
   4. American Society for Non-Destructive Testing (ASNT), ASNT-TC-1A, Recommended Practice, Personnel Qualification, and Certification in Non-destructive Testing.
   5. ASTM A380, Standard Practice for Cleaning, Descaling, and Passivation of Stainless Steel Parts, Equipment, and Systems
   6. ASTM B32, Specification for Solder Metal.
   7. ASTM D4161, Standard Specification for Fiberglass (Glass-Fiber-Reinforced Thermosetting-Resin) Pipe Joints Using Flexible Elastomeric Seals
   8. ASTM D4174, Standard Practice for Cleaning, Flushing, and Purification of Petroleum Fluid Hydraulic Systems
   9. ASTM F2164, Standard Practice for Field Leak Testing of Polyethylene (PE) Pressure Piping Systems Using Hydrostatic Pressure
   10. AWS D1.1/D1.1M, Structural Welding Code-Steel.
   11. ANSI/AWWA C111, Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings.
   12. ANSI/AWWA C206, Field Welding of Steel Water Pipe.
   13. ANSI/AWWA C600, Installation of Ductile Iron Water Mains and Their Appurtenances.
   14. ANSI/AWWA C606, Grooved and Shouldered Joints.
   15. ANSI/AWWA C651, Disinfecting Water Mains.
   16. AWWA M9, Concrete Pressure Pipe.
   17. AWWA M11, Steel Pipe - A Guide for Design and Installation.
   18. AWWA M23, PVC Piping - Design and Installation.
   19. AWWA M41, Ductile-Iron Pipe and Fittings.
   20. AWWA M45, Fiberglass Pipe Design.
   21. AWWA M55, PE Pipe - Design and Installation.
   22. SAE J1227, Method for Assessing the Cleanliness Level of New Hydraulic Fluid.

1.3 QUALITY ASSURANCE

A. Regulatory Requirements:
   1. Comply with requirements and recommendations of authorities having jurisdiction over the Work.

1.4 SUBMITTALS

A. Action Submittals: Submit the following:
   1. Shop Drawings:
      a. Detailed drawings in plan and, as applicable, section.
      b. Details of piping, valves, supports, accessories, specials, joints, harnessing, and main anchor supports, and connections to existing piping, structures, equipment, and appurtenances.
   2. Testing Plans, Procedures, and Testing Limitations
      a. Submit description of proposed testing methods, procedures, and apparatus, and obtain ENGINEER's approval prior to testing.

B. Informational Submittals: Submit the following:
   1. Certificates:
      a. Submit a certificate, signed by manufacturer of each product, certifying that product complies with applicable referenced standards.
   2. Source Quality Control Submittals:
      a. Submit copies of testing report for each test.
   3. Site Quality Control Reports:
      a. Submit copies of testing report for each test.

C. Closeout Submittals: Submit the following:
   1. Record Documentation:
      a. Maintain accurate and up-to-date record documents showing field and Shop Drawing modifications. Record documents for exposed piping Work shall show actual location of all piping and appurtenances on a copy of the Drawings, unless otherwise approved by ENGINEER.
      b. Record documents shall show piping with elevations referenced to the project datum and dimensions from permanent structures. For straight runs of pipe provide offset dimensions as required to document pipe location.
      c. Include section drawings with exposed piping record documents when the Contract Documents include section Drawings.
      d. Conform to Section 01 78 39, Project Record Documents.

1.5 DELIVERY, STORAGE AND HANDLING

A. Delivery:
   1. Deliver products to Site to ensure uninterrupted progress of the Work.
   2. Upon delivery, inspect pipe and appurtenances for cracked, gouged, chipped, dented, and other damage and immediately remove damaged products from Site.
   3. Conform to requirements of Section 01 65 00, Product Delivery Requirements.

B. Storage:
   1. Store products for convenient access for inspection and identification. Store products off the ground using pallets, platforms, or other supports. Protect packaged products from corrosion and deterioration.
   2. Pipe and fittings other than thermoplastic materials may be stored outdoors without cover. Thermoplastic pipe and fittings stored outdoors shall be covered.
   3. Conform to requirements of Section 01 66 00, Product Storage and Handling Requirements.

C. Handling:
   1. Handle pipe, fittings, specials, and accessories carefully with approved handling devices. Do not drop or roll material of delivery vehicles. Do not otherwise drop, roll, or skid piping.
   2. Avoid unnecessary handling of pipe.
   3. Keep pipe interiors free of dirt and foreign matter.
   4. Protect interior linings and exterior coatings of pipe and fittings from damage. Replace pipe and fittings with damaged lining regardless of cause of damage. Repair damaged coatings.
   5. Conform to requirements of Section 01 65 00, Product Delivery Requirements.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Piping materials are specified in the Exposed Piping Schedule at the end of this Section. Piping materials shall conform to Specification for each type of pipe and piping appurtenances in applicable sections of Division 40, Process Integration.

B. Markings and Identification:
   1. Pipe Markings:
      a. Clearly mark each piece of pipe or fitting with a designation conforming to that shown on the approved Shop Drawings.
      b. Manufacturer shall cast or paint on each length of pipe and each fitting the pipe material, diameter, and pressure or thickness class.
   2. Pipe Identification Markers and Arrows: Refer to Section 10 14 00, Signage.

C. Appurtenances: Provide products that comply with:
   1. Section 40 05 07, Pipe Hangers and Supports.

PART 3 - EXECUTION

3.1 INSPECTION

A. Examine conditions under which the Work is to be installed and notify ENGINEER in writing of conditions detrimental to the proper and timely completion of the Work. Do not proceed with the Work until unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. General:
   1. Install piping as shown, specified and as recommended by the pipe and fittings manufacturer.
   2. If there is a conflict between manufacturer's recommendations and the Contract Documents, request in writing instructions from ENGINEER before proceeding.
   3. Provide pipe manufacturer's installation specialist at Site as specified on this Section.

B. Temporary Blind Flanges, Plugs, Caps, and Bulkheads:
   1. Temporarily plug installed pipe at the end of each day of work or other interruption of pipe installation to prevent entry of animals, liquids, and persons into pipe, and entrance or insertion of deleterious materials into pipe.
   2. Install standard plugs in all bells at dead ends, tees, and crosses. Cap all spigot and plain ends.
   3. Fully secure and block blind flanges, plugs, caps, and bulkheads installed for testing, designed to withstand specified test pressure.
   4. Where plugging is required for phasing of Work or subsequent connection of piping, install watertight, permanent type blind flanges, plugs, caps, or bulkhead acceptable to ENGINEER.

C. Piping Installation:
   1. Conform to manufacturer's instructions and requirements of standards and manuals listed in this Section, as applicable:
      a. Ductile Iron Pipe: ANSI/AWWA C600, AWWA M41.
      d. Thermoplastic Pipe: AWWA M23
   2. Install straight runs true to line and elevation.
   3. Install vertical pipe truly plumb in all directions.
   4. Install piping parallel or perpendicular to walls of structures. Piping at angles and 45 degree runs across corners of structures will not be accepted unless specifically shown on the Contract Documents or approved by the ENGINEER.
   5. Install small diameter piping generally as shown when specific locations and elevations are not indicated. Locate such piping as required to avoid ducts, equipment, beams, and other obstructions.
   6. Install piping to leave all corridors, walkways, work areas, and similar spaces unobstructed. Unless otherwise approved by ENGINEER provide a minimum

headroom clearance under piping and pipe supports of 7.5 feet. Clearances beneath piping shall be measured from the outermost edge of piping, flanges or other type of joint that extends beyond the nominal outside diameter of piping.

7. Protect and keep clean interiors, fittings, and valves of pipe that will convey potable water, chemicals, and other pipe designated by ENGINEER.
8. Cutting: Cut pipe from measurements verified at Site. Field cut pipe, where required, with a machine specially designed for cutting type of pipe being installed. Make cuts carefully without damage to pipe, coating, or lining, and with a smooth end at right angles to axis of pipe. Cut ends of push-on joint type pipe shall be tapered and sharp edges filed off smooth. Do not flame-cut pipe.
9. Additional General Requirements for Thermoplastic Piping:
    a. Utilize wide band supports as recommended by pipe manufacturer and approved by ENGINEER to minimize localized stresses.
    b. Provide piping passing through walls with a sleeve of wearing material to prevent abrasion damage to piping.
    c. Provide anchored supports at elbows, valves, bends in piping, and at connections to equipment and tanks.
    d. Spacing of supports shall be in accordance with the manufacturer's published recommendations at maximum design operating temperature of pipe.
    e. Provide U-clamps with wide band circumferential contact.
    f. Provide guides on long runs of piping to maintain alignment and reduce chance of elastic failure of pipe. Space guides as recommended by pipe manufacturer.
    g. Provide anchored supports to restrain joints that allow expansion. Minimize use of bellows style joints. Where required and approved by the ENGINEER provide bellows style joints with low axial force to take up pipe expansion. Flexible connectors may be used to absorb thermal movement when approved in writing by ENGINEER.

D. Jointing Pipe:
    1. General:
        a. Make joints in accordance with pipe manufacturer's recommendations and Contract Documents.
        b. Cut piping accurately and squarely and install without forcing or springing.
        c. Ream out pipes and tubing to full inside diameter after cutting. Remove all sharp edges on end cuts.
        d. Remove all cuttings and foreign matter from inside of pipe and tubing before installation. Thoroughly clean all pipe, fittings, valves, specials, and accessories before installing.
    2. Ductile Iron Flanged Joints:
        a. Assemble flanged joints using ring-type gaskets, with thickness as recommended by pipe manufacturer but not less than 1/8-inch thick, for raised-face flanges. Use full-face gaskets for flat-face flanges, unless

otherwise approved by ENGINEER or recommended by pipe manufacturer. Gaskets shall be suitable for the service intended in accordance with the manufacturer's ratings and instructions. Gaskets shall be properly centered.

b. Tighten bolts in a sequence that provides equal distribution of bolt loads.

c. Length of bolts shall be uniform. Bolts shall not project beyond the nut more than 1/4-inch or fall short of the nut when fully taken up. Machine-cut ends of bolts to be neatly rounded. Do not use washers.

d. Prior to assembly of flanged joints, lubricate bolt threads and gasket faces.

e. Alternately tighten bolts 180 degrees apart to compress the gasket evenly.

f. After assembly, coat all bolts and nuts, except stainless steel bolts and nuts, with same coating specified in Section 09 91 00, Painting, for material of pipe and fittings being joined.

3. Thermoplastic Pipe Joints:

a. Solvent Cement Welded Joints:

1) Bevel pipe ends and remove all burrs before making joint. Clean pipe and fittings thoroughly. Do not make solvent cement joints if temperature is below 40 degrees F. Do not make solvent cement welded joints in wet conditions.

2) Use solvent cement supplied or recommended by pipe manufacturer.

3) Apply joint primer and solvent cement and assemble joints in accordance with recommendations and instructions of manufacturer of joint materials and pipe manufacturer.

4) Implement appropriate safety precautions when using joint primers and solvent cements. Allow air to circulate freely through pipelines to allow solvent vapors to escape. Slowly admit fluid when flushing or filling pipelines to prevent compression of gases within pipes.

b. Threaded Joints:

1) Cut pipe square and smooth and remove burrs or raised edges with a knife or file.

2) Hold pipe firmly in a pipe vise. Protect pipe at the point of grip by inserting a rubber sheet or other material between pipe and vise.

3) Thread pipe in accordance with pipe manufacturer's recommendations. Brush threads clean of chips and ribbons.

4) After threading pipe, starting with second full thread, and continuing over thread length, wrap 100-percent virgin TFE (Teflon) thread tape in direction of threads. Overlap each wrap by one-half width of tape.

5) After application of the TFE thread tape, screw fitting or coupling onto the pipe end to be joined and tighten by hand. Using a strap wrench only, further tighten connection an additional one to two threads past hand tightness.

c. Bell and Spigot Joints:

1) Bevel pipe ends, remove all burrs, and provide a reference mark at correct distance from pipe end before making joint.

2) Clean spigot end and bell thoroughly before making the joint. Insert

O-ring gasket while ensuring that gasket is properly oriented. Lubricate spigot with manufacturer's recommended lubricant. Do not lubricate bell and O-ring. Insert spigot end of pipe carefully into bell until reference mark on spigot is flush with bell.

E. Installing Valves and Accessories:
   1. Provide supports for large valves, flow meters, and other heavy items as shown or required to prevent strain on adjoining piping.
   2. Position flow measuring devices in pipe lines so that they have the amount of straight upstream and downstream runs recommended by the flow measuring device manufacturer, unless specific location dimensions are shown.
   3. Position swing check valves and butterfly valves so that they do not conflict with upstream and downstream elements of the piping system.

F. Unions:
   1. Install dielectric unions where dissimilar metals are connected, except for bronze or brass valves in ferrous piping.
   2. Provide a union downstream of each valve with screwed connections.
   3. Provide screwed or flanged unions at each piece of equipment, where shown, and where necessary to install or dismantle piping.

G. Transitions from One Type of Pipe to Another:
   1. Provide all necessary adapters, specials, and connection pieces required when connecting different types and sizes of pipe or connecting pipe made by different manufacturers.

H. Closures:
   1. Provide closure pieces, such as blind flanges and caps, shown or required to complete the Work.

3.2 THRUST RESTRAINT

A. Provide thrust restraint on all pressure piping systems and where otherwise shown or specified.

B. Thrust restraints shall be designed for axial thrust exerted by test pressure specified in the Exposed Piping Schedule at end of this Section.

3.3 WORK AFFECTING EXISTING PIPING

A. Location of Existing Piping:
   1. Locations of existing piping shown on Drawings is approximate.
   2. Determine the true location of existing piping to which connections are to be made, crossed, and that could be disturbed, and determine location of other facilities that could be affected by the Work.

B. Taking Existing Pipelines Out of Service:
   1. Conform to Section 01 14 16, Coordination with Owner's Operations.

C. Work on Existing Pipelines:
   1. Cut or tap pipes as shown or required with machines and tools specifically designed for cutting or tapping pipelines.
   2. Install temporary plugs to prevent entry of mud, dirt, water, and debris into pipe.
   3. Provide necessary adapters, sleeves, fittings, pipe, and appurtenances required to complete the Work.
   4. Conform to applicable requirements of Section 01 14 16, Coordination with Owner's Operations and Section 01 73 24, Connections to Existing Facilities.

3.4 PAINTING

A. Field painting shall conform to Section 09 91 00, Painting.

3.5 FIELD QUALITY CONTROL

A. Testing, General:
   1. Test all piping, except as exempted in the Exposed Piping Schedule.
   2. Notification:
      a. Notify ENGINEER at least 48 hours prior to testing.
      b. When authorities having jurisdiction are to witness tests, notify ENGINEER and authorities having jurisdiction in writing at least 48 hours in advance of testing.
   3. Conduct all tests in presence of ENGINEER.
   4. Remove or protect pipeline-mounted devices that could be damaged by testing.
   5. Provide all apparatus and services required for testing, including:
      a. Test pumps, compressors, hoses, calibrated gages, meters, test containers, valves, fittings, and temporary pumping systems required to maintain OWNER's operations.
      b. Temporary bulkheads, bracing, blocking, and thrust restraints.
   6. Provide air if an air test is required, power if pumping is required, and gases if gases are required.
   7. Unless otherwise specified, OWNER will provide fluid required for hydrostatic testing. CONTRACTOR shall provide means to convey fluid for hydrostatic testing into the pipe being tested. CONTRACTOR shall provide fluid for other types of testing required.
   8. Repair observed leaks and repair pipe that fails to meet acceptance criteria. Retest after repair.
   9. Unless otherwise specified, testing shall include existing piping systems that connect with new piping system. Test existing pipe to nearest valve. Piping not installed by CONTRACTOR and that fails the test shall be repaired upon authorization of ENGINEER or OWNER. Repair of existing piping will be paid as extra work unless otherwise specified.

10. When testing existing chlorine gas and sulfur dioxide gas systems to the nearest isolation valve, provide a tee in the line adjacent to valve. Branch outlet on tee shall be provided with a valve and used for cleaning, testing, draining, and drying pipe. Unless otherwise indicated, existing chlorine or sulfur dioxide system shall not be shut down during testing or for installing tee and valve. Prior to placing the pipeline in service, valve on the branch outlet of tee shall be plugged or sealed with a blind flange or threaded plug. Repair damage to system as a result of this Work at no extra cost to OWNER.

B. Test Schedule:
   1. Refer to the Exposed Piping Schedule for type of test required and required test pressure.
   2. Unless otherwise specified, the required test pressures are at lowest elevation of pipeline segment being tested.
   3. For piping not listed in Exposed Piping Schedule:
      a. Hydrostatically test pipe that will convey liquid at a pressure greater than five psig. Provide process air pipe test for pipe that will convey air or gas under pressure or vacuum, except chlorine gas, which requires a separate test.
      b. Disinfect for bacteriological testing piping that conveys potable water.
   4. Test Pressure:
      a. Use test pressures listed in Exposed Piping Schedule.
      b. If test pressure is not listed in Exposed Piping Schedule, or if a test is required for piping not listed in the Exposed Piping Schedule, test pressure will be determined by the ENGINEER based on the maximum anticipated sustained operating pressure and the methods described in the applicable ANSI/AWWA manual or standard that applies to the piping system.

C. Hydrostatic Testing:
   1. Preparation for Testing:
      a. For thermoplastic pipe, follow procedures described in Section 7 of ANSI/AWWA Standard C605.
      b. For other piping follow procedures described in AWWA Manual M9. A wetting period is not required for pipe that is not cement mortar-lined.
      c. Prior to testing, ensure that adequate thrust protection is in place and all joints are properly installed.
      d. Piping for Hydraulic Fluid, Lube Oil, and Diesel Fuel: Hydrostatically test system using the fluid with which system will function permanently. Allowable leakage is zero. For fluid power systems, manufacturer shall supervise installation and testing of system components, including field piping.
   2. Test Procedure:
      a. Fill pipeline slowly to minimize air entrapment and surge pressures. Fill rate shall not exceed one foot of pipe length per second in the pipe being tested.

b. Expel air from pipe as required. Obtain approval of ENGINEER prior to tapping pipe for expelling air.
c. Examine joints and valves, and make repairs to eliminate visible leakage.
d. After specified wetting period, add fluid as required to pressurize line to required test pressure. Maintain test pressure for a stabilization period of ten minutes before beginning test.
e. Timed test period shall not begin until after the pipe has been filled, exposed to the required wetting period, air has been expelled, and pressure stabilized.
f. Timed Test Period: After the stabilization period, maintain test pressure for at least two hours. During timed testing period, add fluid as required to maintain pressure within five psig of required test pressure. For HDPE pipe, after three hour expansion phase, reduce test pressure by ten psig and do not add liquid. The test pressure shall then remain steady for one hour, indicating no leakage.
g. Pump from a test container to maintain test pressure. Measure volume of fluid pumped from test container and record on test report. Record pressure at test pump at fifteen minute intervals for duration of test.

3. Allowable Leakage Rates: Leakage is defined as the quantity of fluid supplied to pipe segment being tested to maintain pressure within five psi of the test pressure during timed test period. Allowable leakage rates for piping are:
   a. No Leakage: Pipe with flanged, welded, fused, threaded, soldered, or brazed joints.
   b. Rates based on formula or table in AWWA Manual M41:
      1) Metal and fiberglass pipe joined with rubber gaskets as sealing members, including the following joint types:
         a) Bell and spigot and push-on joints.
         b) Mechanical joints.
         c) Bolted sleeve type couplings.
         d) Grooved and shouldered couplings.
   c. Rates based on make-up allowance in AWWA Manual M9:
      1) Prestressed concrete cylinder pipe and other types of concrete pipe joined with O-ring rubber gasket sealing members.
   d. Rates based on formula or table in ANSI/AWWA C605:
      1) Plastic pipe joined with O-ring gasket sealing members.

D. Bacteriological Testing:
   1. Bacteriological testing for potable water lines, finished water lines, and other piping per Exposed Piping Schedule, is specified in Article 3.6 of this Section.

3.6 CLEANING AND DISINFECTION

A. Cleaning, General: Clean pipe systems as follows:
   1. Thoroughly clean all piping, including flushing with water, dry air, or inert gas as required, in a manner approved by ENGINEER, prior to placing in service. Flush chlorine solution and sodium hypochlorite piping with water.

2. Piping 24-inch diameter and larger shall be inspected from inside and debris, dirt and foreign matter removed.
3. For piping that requires disinfection and has not been kept clean during storage or installation, swab each section individually before installation with a five percent hypochlorite solution.

B. Cleaning of Hydraulic and Fluid Power Oil Systems: Upon completion of field piping, but before connection to control components, hydraulic and fluid power oil systems shall be flushed and cleaned by circulating special flushing oil through the system. Flushing oil and procedures shall comply with ASTM D4174. System shall be cleaned such that internal contamination of system, when tested using procedures specified in SAE J1227, Section 2.3, shall not exceed the Allowable Cleanliness Level (ACL). Unless otherwise specified, ACL value shall be established by manufacturer of major hydraulic system components in accordance with SAE J1227, Section 9.1.

C. Disinfection:
1. Disinfect all potable and finished water piping.
2. A suggested procedure for accomplishing complete and satisfactory disinfection is specified below. Other procedures may be considered for acceptance by ENGINEER.
   a. Prior to disinfection, clean piping as specified and flush thoroughly.
   b. Conform to procedures described in ANSI/AWWA C651. Continuous feed method of disinfecting shall be used, unless alternative method is acceptable to ENGINEER.
3. Water for initial flushing, testing, and disinfection will be furnished by OWNER. CONTRACTOR shall provide all temporary piping, hose, valves, appurtenances, and services required. Cost of water required for re-disinfection will be paid by CONTRACTOR to OWNER at the water utility's standard rates.
4. Chlorine shall be provided by CONTRACTOR.
5. Bacteriologic tests will be performed by OWNER. A certified test laboratory report will be provided to CONTRACTOR, if requested.
6. Chlorine concentration in the water entering the piping shall be between 50 and 100 ppm, such that a minimum residual concentration of 25 mg/l remains after a 24-hour retention period. Disinfect the piping and all related components. Repeat as necessary to provide complete disinfection.
7. After required retention period, the chlorinated water shall be flushed to a closed drain line, unless otherwise directed by ENGINEER. Properly dispose of chlorinated water in accordance with applicable regulations. Do not discharge chlorinated water to storm sewers, ditches, or overland.

3.7 EXPOSED PIPING SCHEDULE

A. The schedules listed below, following the "End of Section" designation, are a part of this Specification section.
   1. Table 40 05 05-A, Exposed Piping Schedule.

+ + END OF SECTION + +

TABLE
40 05 05-A, EXPOSED PIPING SCHEDULE

Service	Diameter (inch)	Material	Interior Lining	Exterior Coating	Pressure Class/ Thickness	Joint	Test	Remarks
FW	ALL	DI	CL	P	CLASS 53	FLG	HYD (150 psig) DBT	
AVD	4	PVC	--	--	SCHEDULE 80	FLG	NR	
D	ALL	PVC	--	--	SCHEDULE 80	SW	NR	

The following abbreviations are used in the Exposed Piping Schedule.

A. Service Abbreviations

Service	Abbrev.		Service	Abbrev.
Finished Water	FW		Drain	D
Air Valve Drain	AVD			

B. Material Abbreviations

Material	Abbrev		Material	Abbrev.
Ductile Iron	DI		Polyvinyl Chloride	PVC

C. Lining/Coating Abbreviations

Lining	Abbrev		Coating	Abbrev.
Cement Mortar Lined	CL		Painted	P

D. Joint Abbreviations

Joint Type	Abbrev		Joint Type	Abbrev.
Solvent Weld	SW		Flanged	FLG

E. Test Abbreviations

Test	Abbrev		Test	Abbrev.
Hydrostatic Test (test pressure in psig)	HYD ( )		Disinfection and Bacteriological Testing	DBT
No Test Required	NR			

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SECTION 40 05 06

COUPLINGS, ADAPTERS, AND SPECIALS FOR PROCESS PIPING

PART 1 - GENERAL

1.1 DESCRIPTION

A. Scope:
   1. CONTRACTOR shall provide all labor, materials, equipment, and incidentals as shown, specified, and required to furnish and install all couplings, adapters, and specials for process piping.

B. Coordination:
   1. Review installation procedures under this and other Sections and coordinate installation of items that must be installed with or before couplings, adapters, and specials for process piping Work.

C. Related Sections:
   1. Section 09 91 00, Painting.
   3. Section 40 05 05, Exposed Piping Installation.

1.2 REFERENCES

A. Standards referenced in this Section are:
   1. ANSI B16.1, Cast-Iron Pipe Flanges and Flanged Fittings.
   2. ANSI B16.39, Malleable Iron Threaded Pipe Unions.
   3. ASME B31, Standards of Pressure Piping.
   4. ASTM A53/A53M, Specification for Pipe, Steel, Black and Hot-dipped, Zinc-Coated, Welded and Seamless.
   5. ASTM A105/A105M, Specification for Carbon Steel Forgings and Piping Applications.
   6. ASTM B169/B169M Specification for Aluminum Bronze Sheet, Strip, and Rolled Bar.
   7. ASTM B650, Specification for Electro-Deposited Engineering Chromium Coatings of Ferrous Substrates.
   8. ASTM F593, Specification for Stainless Steel Bolts, Hex Cap Screws, and Studs
   9. AWWA C606, Grooved and Shouldered Joints.

1.3 QUALITY ASSURANCE

A. Qualifications:
   1. Manufacturer shall have at least five years experience producing substantial similar products to those specified and shall be able to provide documentation

of at least five installations in satisfactory operation for at least five years each.

B. Component Supply and Compatibility:
   1. Obtain each type of coupling, adapter, and special for process piping product included in this Section, regardless of component manufacturer, from a single couplings, adapters, and specials manufacturer.
   2. Supplier shall prepare, or review, and approve all submittals for components furnished under this Section.
   3. Components shall be suitable for specified service conditions and be integrated into overall assembly by the Supplier.

1.4 SUBMITTALS

A. Action Submittals: Submit the following:
   1. Shop Drawings:
      a. Submit piping layout Shop Drawings in accordance with Section 40 05 05, Exposed Piping Installation.
   2. Product Data:
      a. Submit product data on each type of coupling, expansion joint, and other piping specialties and accessories, including gaskets, hardware, and appurtenances sufficient to demonstrate compliance with the Contract Documents.

B. Informational Submittals: Submit the following:
   1. Certificates:
      a. When requested by ENGINEER submit certificate attesting to compliance with standards referenced in this Section, signed by manufacturer.
   2. Manufacturer's Instructions:
      a. Provide instructions for handling, storing, installing, and adjusting of products.
   3. Source Quality Control:
      a. When requested by ENGINEER, submit results of source quality control tests.
   4. Qualifications Statements:
      a. Submit qualifications of manufacturer when requested by ENGINEER.

1.5 DELIVERY, STORAGE AND HANDLING

A. Refer Section 40 05 05, Exposed Piping Installation.

PART 2 – PRODUCTS

2.1 TAPPING SLEEVES

A. Fabricated Steel Tapping Sleeves:
   1. Pressure and Service: Same as connected piping.
   2. Products and Manufacturers: Provide products of one of the following:
      a. Style FTS420, as manufactured by Romac Industries, Inc.
      b. Or equal.
   3. Material: Carbon Steel, Grade A36.
   4. Gaskets: Suitable for specified service, as recommended by manufacturer.
   5. Bolts and Nuts: Trackhead bolts, heavy hex nuts, Type 304 stainless steel.
   6. Outlet Gaskets: SBR per ASTM D 2000, compounded for water service use. For 3"-12" size-on-size flanges, the gaskets are reinforced with a metal ring. Larger than 12" size-on-size sleeves use a square profile o-ring NBR per ASTM D2000 set in a full body thickness cavity.
   7. Test Plug: 3/4-inch NPT type 304 stainless steel test plug.
   8. Flange Gaskets: 3"-12" full face SBR per ASTM D 2000, compounded for water service use.
   9. Coating: Per Section 09 91 00, Painting.
   10. Flange: AWWA Class "D" plate flange, ANSI Class 150 Drilling, proper recessing for tapping valves.

2.2 PAINTING

A. Shop Painting:
   1. Clean and prime-coat ferrous metal surfaces of products in the manufacturer's shop in accordance with Section 09 91 00, Painting, unless otherwise specified in this Section
   2. Coat machined, polished and non-ferrous surfaces bearing surfaces and similar unpainted surfaces with corrosion prevention compound that shall be maintained during storage and until products are placed into operation.

B. Field painting shall conform to Section 09 91 00, Painting.

PART 3 - EXECUTION

3.1 INSPECTION

A. Inspect materials for defects in material and workmanship. Verify compatibility of products with pipe, fittings, valves, and appurtenances.

3.2 INSTALLATION

A. Installation:
   1. Install piping specialties in accordance with the Contract Documents and manufacturer's instructions.
   2. For exposed installations, refer to Section 40 05 05, Exposed Piping Installation.

B. Adjust expansion joints as required to ensure that expansion joints will be fully extended when ambient temperature is at minimum operating temperature, and fully compressed at maximum operating temperature for the system in which expansion joints are installed.

++ END OF SECTION ++

SECTION 40 05 07

PIPE HANGERS AND SUPPORTS

PART 1 - GENERAL

1.1 DESCRIPTION

A. Scope:
   1. CONTRACTOR shall provide all labor, materials, equipment, and incidentals as shown, specified and required to design, furnish, and install all hangers, supports and appurtenances necessary to complete the Work.

B. Coordination:
   1. Review installation procedures under other Sections and coordinate the installation of items that must be installed with the pipe hangers and supports Work.

C. Related Sections:
   1. Section 03 00 05, Concrete.
   2. Section 05 05 33, Anchor Systems
   3. Section 05 50 13, Miscellaneous Metal Fabrications.
   4. Section 09 91 00, Painting.

1.2 REFERENCES

A. Standards referenced in this Section are listed below:
   1. American Society for Testing and Materials, (ASTM).
      a. ASTM A 575, Specification for Steel Bars Carbon, Merchant Quality, M-Grades.
      b. ASTM E 84, Test Method for Surface Burning Characteristics of Building Materials.
   2. Federal Specification, (FS).
      a. FS A-A-1192, Hangers, Pipe.
   3. Manufacturers Standardization Society of the Valve and Fittings Industry, (MSS).
      a. MSS SP 58, Pipe Hangers and Supports-Materials, Design and Manufacture.
      b. MSS SP 69, Pipe Hangers and Supports - Selection and Application.
   4. Underwriters' Laboratories, Inc., (UL).
      a. UL 203, Pipe Hanger Equipment for Fire Protection Service.

1.3 QUALITY ASSURANCE

A. Each type of pipe hanger or support shall be the product of one manufacturer.

B. Component Supply and Compatibility:
   1. Obtain all equipment included in this Section regardless of the component manufacturer from a single pipe hangers and supports manufacturer.
   2. The pipe hangers and supports equipment manufacturer to review and approve or to prepare all Shop Drawings and other submittals for all components furnished under this Section.
   3. All components shall be specifically constructed for the specified service conditions and shall be integrated into the overall assembly by the pipe hangers and supports equipment manufacturer.

1.4 SUBMITTALS

A. Action Submittals: Submit the following:
   1. Shop Drawings:
      a. Detailed drawings showing all hangers and supports for each piping system specified. Shop Drawings shall show location, installation, material, loads or forces, and deflection of all hangers and supports.
      b. Each pipe system shall be analyzed for all loads and forces on the hangers and supports. Provide calculations of reaction forces to the structure to which they are fastened. Provide confirmation that hanger systems comply with support requirements and codes.
      c. Submit and coordinate these with Shop Drawings required for all piping systems.

1.5 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.

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. Store materials in covered storage off the ground and prevent condensation.

C. Acceptance at Site:
   1. All boxes, crates and packages shall be inspected by CONTRACTOR upon delivery to the Site. CONTRACTOR shall notify ENGINEER, in writing, if any loss or damage exists to equipment or components. Replace loss and repair damage to new condition in accordance with manufacturer's instructions.

PART 2 - PRODUCTS

2.1 GENERAL

A. Hangers and supports shall meet with the following requirements:
   1. Standard and fabricated hangers and supports shall be furnished complete with necessary inserts, bolts, nuts, rods, washers, and other accessories.
   2. Generally, run piping in groups where practicable and parallel to building wall. Provide minimum clearance of 1-inch between pipe and other work.
   3. Install hangers or supports at all locations where pipe changes direction.
   4. All hangers and supports shall be capable of adjustment after placement of piping.
   5. Different types of hangers or supports shall be kept to a minimum.
   6. All suspended or supported ductile iron pipe shall have a hanger or support adjacent to each hub.
   7. Support vertical piping at each floor and between floors by stays or braces to prevent rattling and vibration.
   8. Hanger rods shall be straight and vertical. Chain, wire, strap or perforated bar hangers shall not be used. Hangers shall not be suspended from piping.
   9. Maximum support spacing unless otherwise shown or approved for standard weight steel pipe shall be as follows:

Pipe Size (inches)	Maximum Pipe Span [1] (feet)			
	Steel	Copper	Plastic [2]	Cast/Ductile Iron [4]
3/8 to 3/4	5	6	Cont. [3]	-
1	6	6	5	-
1-1/4	6	6	5	-
1-1/2	6	6	5	-
2	10	10	5	-
2-1/2	10	10	5	-
3	10	10	5	-
4	12	12	5	12 feet for pressure pipe
6	12	12	5	
8	12	12	5	
10	12	-	5	
12	12	-	10	
14	12	-	-	
16	12	-	-	
18	12	-	-	10 feet for soil pipe
20	12	-	-	
24	12	-	-	

[1]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.

[2]Span shown is for Schedule 80 CPVC pipe at 100°F. Spans for other plastics, other CPVC pipe Schedules and pipes at higher temperatures shall be shortened in accordance with the pipe manufacturer's recommendations.

[3]Continuous means pipe shall be in unistrut or similar channel.

[4] Pipe hanger and support selection shall be as shown and in this Section.

10. Maximum support spacing, unless otherwise shown for plastic pipe at ambient temperature, shall be one-half of the values specified for steel pipe.
11. Plastic pipe at temperature greater than 130°F shall be continuously supported in a metal cradle or tray.
12. Where proper hanger or support spacing does not correspond with joist or rib spacing, structural steel channels may be attached to joists or ribs and pipes suspended there from.
13. Prevent contact between dissimilar metals when supporting copper tubing, by use of copper plated, rubber or vinyl coated, or stainless steel hangers or supports.
14. Isolate thin walled stainless steel piping from carbon steel by use of plastic coated hangers or supports or by taping at points of contact with PVC or vinyl.
15. Supports and hangers shall be of a material that is compatible with the fluid being conveyed in such pipe being supported.
16. Anchors for pipe support systems shall be compatible or protected by a coating system which is compatible with the fluid being conveyed in such pipe being supported.

B. Expansion compensation shall be designed for individual exposed piping systems with the following Design Criteria:
   1. $\Delta L = L \times \Delta T \times \alpha$
      a. Where ΔL = pipe length change (inches).
      b. L = pipe length between anchors (inches).
      c. ΔT = 100 (F).
      d. α = coefficient of thermal expansion (inches/inches/F).
   2. Expansion compensation shall be designed as an integral part of the piping hanger, support and anchorage system.
   3. Expansion compensation shall be achieved via expansion joints specified in Section 40 05 06, Couplers, Adapters, and Specials for Process Piping.

2.2 HANGERS AND SUPPORTS

A. Hangers and supports where shown shall be in accordance with detail drawings. Hangers and supports not shown shall be in accordance with MSS SP 58.

B. Products and Manufacturers: Provide one of the following:

Type	Description	Manufacturers
Adjustable wrought clevis	Hangers, ½ inch through 30 inch Pipe	Figure 260 by Grinnell Figure B3100 or B3102 by B-Line
Carbon Steel Pipe Clamp	Riser Clamps, ½ inch through 30 inch Pipe	Figure 261 by Grinnel. Figure B3373 by B-Line
Cast iron saddle	Pipe Saddles, 1-1/2 inch through 36 inch Pipe	Figure 258 by Grinnell Figure B3095 by B-Line
Cast iron saddle with steel yoke and nuts	Pipe Stanchion Saddle, 2-1/2 inch through 36 inch Pipe	Figure 259 by Grinnell Figure B3090 by B-Line
Cast iron saddle and reducer with nipple	Adjustable Pipe Saddle Support, 2-1/2 inch through 36 inch Pipe	Figure 264 by Grinnell Figure B3093 by B-Line
Fabricated heavy duty steel bracket	Wall Brackets, ½ inch through 36 inch Pipe	Figure 199 by Grinnell Figure B3067 by B-Line
Channel Type Pipe Support	Hot dip galvanized steel conforming to ASTM A 570, Grade 33, 1-5/8 inches by 1-5/8 inches by 12 gauge	Figure PS200 by Grinnell
O.D. Tubing Clamp	Strut mounted clamp	Figure PS1200 by Grinnell Figure B2000 by B-Line
Horizontal pipe support at flange	Flange support. Connecting flange must meet ANSI B16.1 Class 125 and ANSI B16.5 Class 155 standards	Figure B3094 with B3088 base Stand by B-Line

2.3 ACCESSORIES

A. Hanger rods shall be made from ASTM A 575, with square head nut on top and running thread on bottom end.

B. Brackets:
   1. Brackets for wall mounting shall conform to MSS SP 58 Type 32.

2.4 PAINTING

A. Clean and prime ferrous metal surfaces in the shop in accordance with the requirements of Section 09 91 00, Painting.

B. Field painting shall conform to the requirements of Section 09 91 00, Painting.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Locate hangers, supports, and accessories to support piping, valves, and at all concentrated loads.

B. Locate hangers, supports, and accessories within maximum span lengths specified to support continuous pipeline runs unaffected by concentrated loadings.

C. Locate hanger, supports to prevent vibration or swaying and to provide for expansion and contraction.
   1. Temperature differential specified in this Section.
   2. Support piping independently so that equipment is not stressed by piping weight or expansion.
   3. For Uninsulated Copper Pipe or Tubing: Clamps and supports, electroplated copper finish. Instrumentation tubing shall be supported in steel or aluminum troughs with covers. All tubing layout and connections shall be as approved by the manufacturer of the equipment.
   4. Uncoated Hangers, Rods and Supports: Dip in zinc chromate primer before installation.
   5. Maximum spacing for horizontal piping:
      a. Steel 1-Inch and Smaller: Seven feet.
      b. Steel 1-1/2-Inch and Larger: Ten feet.
      c. Brass or Copper 3-Inch and Smaller: Seven feet.
      d. Brass or Copper 4-Inch and Larger: Ten feet.
      e. Additional supports at:
         1) Change in direction.
         2) Branch piping and runouts over five feet.
         3) Concentrated loads due to valves, strainers or other similar items.
      f. Maximum support spacing for plastic pipe at ambient temperature shall be one-half the above values.
   6. Hanger types for horizontal piping, except as noted and shown:
      a. Forged steel adjustable clevis type, rod support for all services.
      b. Slide Bases:
         1) Pipe stand, brackets, trapeze or other equivalent structural support.
         2) For piping 2-inches or larger.
      c. For pipe and covering provide:
         1) Saddles for rollers or slide bases.
         2) Protective shields or saddles for all other types of supports.
      d. Threaded Steel Rods:
         1) Two inch vertical adjustment with two nuts each end for positioning and locking.
         2) Size hanger rods according to the schedule below, unless otherwise noted:

Nominal Pipe (Inches)	Rod Diameter (Inches)
2 and less	3/8
2-1/2 to 3-1/2	1/2
4	5/8
6	3/4
8 through 12	7/8
14 through 18	1
20 through 30	1-1/4

3) For Double Rod Hangers: One size smaller than above.
4) Connection to Structure for Piping to 2-Inches: Concrete inserts, or expansion shields in shear into sides of beams.
5) Connection to Structure for Piping 2-1/2-Inch or Larger: Concrete inserts, beam clamps or suitable bridging.

7. Vertical Piping:
   a. Base Support: Base elbow or welded equivalent.
      1) Bearing plate on structural support.
   b. Guides not to exceed:
      1) 25 feet for piping to 2-inches.
      2) 36 feet for piping 2-1/2-inches or larger.
   c. Top Support:
      1) Special hanger or saddle in horizontal connection.
      2) Provisions for expansion.
   d. Intermediate Supports: Steel pipe clamp at floor.
      1) Bolted and welded to pipe.
      2) Extension ends bearing on structural steel or bearing plates.
   e. For Multiple Pipes: Coordinate guides, bearing plates and accessory steel.
8. Insulated Piping:
   a. Horizontal Pipe Shields at Supports:
      1) Minimum 120 degree arc.
      2) Length equal to diameter of insulation 12-inch minimum.
      3) To 6-Inch Pipe Size: No. 18 USSG galvanized steel.
   b. Vertical Pipe Shields at Guides:
      1) Full 360 degree arc, securely banded.
      2) Length equal to diameter of insulation, 12-inch minimum.
      3) To 6-Inch Pipe Size: No. 18 USSG galvanized steel.

D. Install items to be embedded before concrete placement.

E. Fasten embedded items securely to prevent movement during concrete placement.

F. Anchor Systems: Shall be in accordance with Section 05 05 33, Anchor Systems, and the requirements of this Section.

G. Install hangers and support units on piping systems in accordance with manufacturer's recommendations.

H. Adjust hangers and supports and place grout for concrete supports to bring pipelines to specified elevations.

I. Bring all pipe systems up to operating pressures and temperatures. Cycle systems to duplicate operating conditions. Correct all support malfunctions.

++ END OF SECTION ++

SECTION 40 05 08

WALL PIPES, FLOOR PIPES, AND PIPE SLEEVES

PART 1 - GENERAL

1.1 DESCRIPTION

A. Scope:
   1. CONTRACTOR shall provide all labor, materials, equipment and incidentals as shown, specified and required to furnish and install all floor pipes, pipe sleeves, wall pipes, other wall pieces, and escutcheons to complete the Work.

B. Coordination:
   1. Review installation procedures under this and other Sections and coordinate with the installation of floor pipes, pipe sleeves, wall pipes, other wall pieces and escutcheons that must be installed with or within formwork, walls, partitions, ceilings and panels.

C. Related Sections:
   1. Section 03 00 05, Concrete.
   2. Section 07 92 00, Joint Sealants.

1.2 REFERENCES

A. Standards referenced in this Section are listed below:
   1. American National Standards Institute, (ANSI).
      a. ANSI B16.1, Cast-Iron Pipe Flanges and Flanged Fittings.
      b. ANSI B16.4, Gray-Iron Threaded Fittings.
   2. American Water Works Association, (AWWA).
      a. AWWA C104 (ANSI A21.4), Cement-Mortar Lining for Ductile-Iron Pipe and Fittings for Water.
      b. AWWA C110 (ANSI A21.10), Ductile-Iron and Gray-Iron Fittings, for Water.
      c. AWWA C111 (ANSI A21.11), Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings.
      d. AWWA C115 (ANSI A21.15), Flanged Ductile-Iron Pipe with Ductile-Iron or Gray-Iron Threaded Flanges.
      e. AWWA C151 (ANSI A21.51), Ductile-Iron Pipe, Centrifugally Cast, for Water.
      f. AWWA C200, Steel Water Pipe 6-Inches and Larger.

1.3 QUALITY ASSURANCE

A. Component Supply and Compatibility:
   1. Obtain all equipment included in this Section regardless of the component manufacturer from a single wall pipes, floor pipes and pipe sleeves manufacturer.
   2. The wall pipes, floor pipes and pipe sleeves manufacturer to review and approve or to prepare all Shop Drawings and other submittals for all components furnished under this Section.
   3. All components shall be specifically constructed for the specified service conditions and shall be integrated into the overall assembly by the wall pipes, floor pipes and pipe sleeves manufacturer.

1.4 SUBMITTALS

A. Action Submittals: Submit the following:
   1. Shop Drawings:
      a. Detailed drawings and data on all wall and floor pipe, and pipe sleeves. Submit and coordinate these with Shop Drawings required for all piping systems.

1.5 DELIVERY, STORAGE AND HANDLING

A. Comply with the requirements of Section 40 05 05, Exposed Piping Installation.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Mechanical Seals: Provide link type mechanical seals suitable for 20 psi working pressure, corrosive service and accessible from one side, with glass-reinforced nylon pressure plate and stainless steel bolts and nuts.
   1. Products and Manufacturers: Provide one of the following:
      a. Link-Seal, as manufactured by Thunderline Corporation.
      b. Or equal.

E. Floor, Wall and Ceiling Plates:
   1. Bare pipes passing through floors, walls and ceilings in finished rooms: Provide escutcheon plates of cast brass or cast-iron nickel plated, clevis or split ring and hinged with set screws.
   2. Provide plated escutcheon plates of 18-gauge steel for insulated pipes passing through walls and ceilings in finished rooms.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Mechanical Seals: Install as shown and in accordance with approved Shop Drawings.

B. Install floor, wall and ceiling plates in accordance with the manufacturer's recommendations and approved Shop Drawings.

++ END OF SECTION ++

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SECTION 40 05 19

DUCTILE IRON PROCESS PIPE

PART 1 – GENERAL

1.1 DESCRIPTION

A. Scope:
   1. CONTRACTOR shall provide all labor, materials, equipment, and incidentals as shown, specified, and required to furnish ductile iron pipe and fittings.
   2. Extent of piping is shown on the Drawings. Piping schedules in Section 40 05 05, Exposed Piping Installation, specify pipe service, diameter, material, lining, coating, pressure rating, joint type, and testing required.

B. Coordination:
   1. Review installation procedures under this and other Sections and coordinate installation of items to be installed with or before ductile iron pipe Work.

C. Related Sections:
   1. Section 09 91 00, Painting.
   2. Section 40 05 05, Exposed Piping Installation.

1.2 REFERENCES

A. Standards referenced in this Section are:
   1. ANSI B18.2.1, Square and Hex Bolts and Screws Inch Series.
   2. ANSI B18.2.2, Square and Hex Nuts. (Inch Series).
   3. ASTM A193, Alloy Steel and Stainless Steel Bolting Materials for High-Temperature Service.
   4. ASTM A194, Specification for Carbon Steel and Alloy Steel Nuts for Bolts for High-Pressure or High-Temperature Service, or Both.
   5. ASTM A307, Specification for Carbon Steel Bolts and Studs, 60,000 psi Tensile Strength.
   6. ASTM A354, Specification for Quenched and Tempered Alloy Steel Bolts, Studs and Other Externally Threaded Fasteners.
   7. ASTM A563, Specification for Carbon and Alloy Steel Nuts.
   8. ASTM B117, Practice for Operating Salt Spray (Fog) Apparatus.
   9. ASTM C283, Test Methods for Resistance of Porcelain Enameled Utensils to Boiling Acid.
   10. ASTM D714, Test Method for Evaluating Degree of Blistering of Paints.
   11. ASTM D792, Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement.
   12. ASTM D5162, Discontinuity (Holiday) Testing of Non-Conductive Protective Coating on Metallic Substrates.

13. ASTM E96, Test Methods for Water Vapor Transmission of Materials.
14. ASTM G14, Test Method for Impact Resistance of Pipeline Coatings (Falling Weight Test).
15. ASTM G62, Test Methods for Holiday Detection in Pipeline Coatings.
16. ASTM G95, Test Methods for Cathodic Disbondment Test of Pipeline Coatings (Attached Cell Method).
17. ANSI/AWWA C104, Cement-Mortar Lining for Ductile Iron Pipe and Fittings for Water.
18. ANSI/AWWA C110, Ductile Iron and Gray Iron Fittings for Water.
19. ANSI/AWWA C111, Rubber-Gasket Joints for Ductile Iron Pressure Pipe and Fittings.
20. ANSI/AWWA C115, Flanged Ductile Iron Pipe with Ductile Iron or Gray Iron Threaded Flanges.
21. ANSI/AWWA C116, Protective Fusion-Bonded Epoxy Coatings for the Interior and Exterior Surfaces of Ductile Iron and Gray Iron Fittings for Water Service.
22. ANSI/AWWA C151, Ductile Iron Pipe, Centrifugally Cast, for Water.
23. ANSI/AWWA C153, Ductile Iron Compact Fittings, 3 inch through 24 inch and 54 inch through 64 inch for Water Service.
24. ANSI/AWWA C606, Grooved and Shouldered Type Joints.
25. European Standard (EN), EN 598: Ductile Iron Pipe, Fittings, Accessories and Their Joints for Sewerage Applications.
26. MSS-SP 60, Connecting Flange Joint Between Tapping Sleeves and Tapping Valves.
27. NACE RP0188, Discontinuity (Holiday) Testing of New Protective Coatings on Conductive Substrates.
28. NAPF 500-03, Surface Preparation Standard for Ductile Iron Pipe and Fittings Receiving Special External Coatings and/or Special Internal Linings.
29. NSF/ANSI 61, Drinking Water System Components - Health Effects.
30. SSPC PA 2, Measurement of Dry Coating Thickness with Magnetic Gages.
31. SSPC Painting Manual, Volume 1, Para. XIV.

1.3 QUALITY ASSURANCE

A. Qualifications:
   1. Manufacturer:
      a. Manufacturer shall have a minimum of five years successful experience producing ductile iron pipe and fittings and shall be able to show evidence of at least five installations in satisfactory operation in the United States that are similar applications to the specified service.
      b. Lining and coating products shall be manufactured by a firm with a minimum of five years successful experience in protecting pipelines exposed to the specified service conditions , and shall be able to show evidence of at least five installations in satisfactory operation in the United States that are similar applications to the specified service.
      c. When not applied by the manufacturer, lining and coating

Subcontractor shall have a minimum of five years successful experience in the application of the specified linings and coatings for similar applications for the specified service, and shall be able to show evidence of at least five installations in satisfactory operation in the United States.

B. Supply and Compatibility:
   1. Unless otherwise approved, obtain all pipe, fittings, and appurtenances included in this Section from a single ductile iron pipe manufacturer.
   2. Ductile iron pipe manufacturer shall review and approve or prepare all Shop Drawings and other submittals for pipe, fittings, and appurtenances furnished under this Section.
   3. Pipe, fittings, and appurtenances shall be suitable for the specified service and shall be integrated into overall piping system by ductile iron pipe manufacturer.
   4. Ductile iron pipe manufacturer shall be responsible for all products and all factory-applied linings and coatings, whether installed at pipe manufacturer's facility or at manufacturer's Supplier's facility.

C. Regulatory Requirements:
   1. Pipe and fittings, including linings and coatings, that will convey potable water or water that will be treated to become potable, shall be certified by an accredited organization in accordance with NSF/ANSI 61 as being suitable for contact with potable water, and shall comply with requirements of authorities having jurisdiction at Site.

1.4 SUBMITTALS

A. Action Submittals: Submit the following with Shop Drawings required under Section 40 05 05, Exposed Piping Installation:
   1. Shop Drawings:
      a. Detailed drawings and data for pipe, fittings, gaskets, appurtenances, linings, and coatings.
   2. Product Data:
      a. Surface preparation and application reports and procedures as required for lining and coating of pipe and fittings. Ductile iron pipe and fitting manufacturer and manufacturer and applicator of lining and coating, as specified, shall mutually determine recommended surface preparation and application methods, and provide written verification of mutually selected method in the submittals.
   3. Samples:
      a. Submit Sample of pipe and fitting with each type of lining, for use at the Site to verify continuity, surface gloss, and color, as applicable, via visual inspection.
   4. Test Procedures: For linings and coatings in pipe and fittings.

B. Informational Submittals: Submit the following:
   1. Certificates:
      a. Submit certificate signed by manufacturer of each product that product conforms to applicable referenced standards and the Contract Documents.
      b. Submit certificate signed by applicator of the linings and coatings stating that product to be applied conforms to applicable referenced standards and that the applicator shall conform to the Contract Documents.
   2. Source Quality Control Submittals:
      a. Submit results of specified shop tests for pipe, fittings, linings, and coatings.
      b. Lining and coating test coupons.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Refer to Section 40 05 05, Exposed Piping Installation.

PART 2 – PRODUCTS

2.1 MATERIALS

A. General:
   1. Piping systems shall be suitable for their intended use.
   2. Joints shall be as specified in Section 40 05 05, Exposed Piping Installation. If not specified, provide flanged joints for exposed piping and push-on or mechanical joints for buried piping. Provide couplings on pipe with plain or grooved ends where shown or where approved by ENGINEER.

B. Ductile Iron Pipe, Joints, and Fittings:
   1. Flanged Pipe: Fabricate in accordance with ANSI/AWWA C115.
      a. Pressure Rating: As specified in piping schedule in Section 40 05 05, Exposed Piping Installation. If not otherwise specified, use Special Thickness Class 53 for three-inch to 54-inch diameter pipe and Pressure Class 350 for 60-inch and 64-inch diameter pipe.
   2. Pipe Joints:
      a. Flanged Joints: Conform to ANSI/AWWA C110 and ANSI/AWWA C111 capable of meeting the pressure rating or special thickness class, and test pressure specified in piping schedule in Section 40 05 05, Exposed Piping Installation.
         1) Gaskets: Unless otherwise specified, gaskets shall be at least 1/8-inch thick, ring or full-face as required for the pipe, of synthetic rubber compound containing not less than 50 percent by volume nitrile or neoprene, and shall be free from factice, reclaimed rubber, and other deleterious substances. Gaskets shall be suitable for the service conditions specified, specifically designed for use with ductile iron pipe and fittings.

2) Bolts: Comply with ANSI B18.2.1.
   a) Exposed: ASTM A307, Grade B.
   b) Buried or Submerged: ASTM A193, Grade B8M, Class 2, Heavy hex, Type 316 stainless steel.
3) Nuts: Comply with ANSI B18.2.2.
   a) Exposed: ASTM A563, Grade A, Heavy hex.
   b) Buried or Submerged: ASTM A194, Grade B8M, Heavy hex, Type 316 stainless steel.

4. Flanged and Push-On Joint Fittings: Comply with ANSI/AWWA C110 and ANSI/AWWA C111.
   a. Material: Ductile iron.
   b. Pressure rating, gaskets, bolts, and nuts shall be as specified for flanged joints. Pressure rating of fittings shall meet, but not exceed, specified pressure rating or special thickness class of the connected pipe.

C. Lining, General:
   1. Typical Service Conditions:
      a. Surface Preparation: Prepare surface in accordance with recommended method

   2. Surface Preparation:
      a. Initial Surface Inspection: Surface to be lined shall be inspected by pipe and fitting manufacturer and applicator, if applicator is other than pipe and fitting manufacturer. Inspecting parties shall inspect surface to be coated and mutually determine recommended surface preparation method.
      b. Surface Preparation: Prepare surface in accordance with recommended method.
      c. Finished Surface Inspection: Lining applicator shall inspect finished surface prior to application to determine acceptability. If surface is unacceptable, repeat surface preparation as necessary.

D. Cement-mortar Lining:
   1. Where specified in piping schedules included with Section 33 05 05, Buried Piping Installation and Section 40 05 05, Exposed Piping Installation, pipe and fittings shall be lined with bituminous seal coated cement-mortar lining in accordance with ANSI/AWWA C104.

E. Specials:
   1. Transition Pieces:
      a. Provide suitable transition pieces (adapters) for connecting to existing piping.
      b. Unless otherwise shown or indicated, expose existing piping to determine material, dimensions, and other data required for transition pieces.
   2. Taps:
      a. Provide taps where shown or required for small-diameter piping or

instrumentation connections.

b. Provide corporation stops where shown or required.

c. Where pipe wall thickness or tap diameter will not allow engagement of full threads, provide tapping saddle with outlet joints conforming to requirements of Paragraph 2.1.B.3.a of this Section for four-inch through 12-inch diameter pipe, and Paragraph 2.1.B.3.b. for 14-inch through 54-inch diameter pipe.

d. For flanged connections on tapping saddle outlet branch, counterbore flange in accordance with MSS SP-60 dimensions. Inside diameter of outlet shall be 1/4-inch greater than nominal diameter.

3. Tangential Outlets:

a. Provide tangential outlet fittings where shown or indicated.

b. Weld-on fittings are acceptable.

c. Flanged and grooved end joints are not allowed.

2.2 MARKING FOR IDENTIFICATION

A. In addition to identification markings specified in Section 40 05 05, Exposed Piping Installation, also stamp, mark, and identify push-on joint and mechanical joint pipe with:

1. Name or trademark of manufacturer.
2. Weight, class or nominal thickness, and casting period.
3. Country where cast.
4. Year the pipe was produced.
5. Letters "DI" or "Ductile" shall be cast or metal stamped

B. In addition to identification markings specified in Section 40 05 05, Exposed Piping Installation, also stamp, mark, and identify flanged pipe with:

1. Flange manufacturer's mark, size, and letters "DI" cast or stamped on the flanges.
2. Fabricator's mark if other than flange manufacturer.
3. Length and weight.

C. In addition to identification markings specified in Exposed Piping Installation, also stamp, mark, and identify fittings with:

1. Manufacturer's identification.
2. Pressure rating.
3. Nominal diameters of openings.
4. Country where cast.
5. Number of degrees or fraction of the circle on bends.
6. Letters "DI" or "Ductile" cast on them.

2.3 EXTERIOR SURFACE PREPARATION AND COATINGS

A. General Coating Requirements:

1. Coating types are specified in piping schedules in Section 40 05 05, Exposed

Piping Installation.

B. Exposed Pipe and Fittings:
   1. Surface Preparation:
      a. Initial Surface Inspection: Pipe and fitting manufacturer and coating applicator shall inspect surface to be coated and mutually determine recommended NAPF 500-03 surface preparation method.
      b. Surface Preparation: Prepare surface in accordance with recommended NAPF 500-03 method.
      c. Finished Surface Inspection: Prepared surfaces shall be inspected by coating applicator prior to application to determine acceptability of finished surface. If surface is unacceptable, repeat surface preparation and re-application as necessary.
   2. After recommended surface preparation, prime coat exterior ferrous metal surfaces of pipe and fittings in the shop in accordance with Section 09 91 00, Painting.
   3. Field painting shall comply with Section 09 91 00, Painting.

PART 3 – EXECUTION

3.1 INSPECTION

A. Inspect piping to assure that piping is free from defects in material and workmanship. Verify compatibility of pipe, fittings, gaskets, linings, and coatings.

3.2 INSTALLATION AND FIELD QUALITY CONTROL

A. For exposed piping installation and testing, refer to Section 40 05 05, Exposed Piping Installation.

++ END OF SECTION ++

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SECTION 40 05 31

THERMOPLASTIC PROCESS PIPE

PART 1 – GENERAL

1.1 DESCRIPTION

A. Scope:
   1. CONTRACTOR shall provide all labor, materials, equipment, and incidentals as shown, specified, and required to furnish and install thermoplastic piping and fittings.
   2. Extent of piping is shown and shall be in accordance with piping schedules in Section 40 05 05, Exposed Piping Installation.

B. Coordination:
   1. Review installation procedures under this and other Sections and coordinate installation of items to be installed with or before thermoplastic piping Work.

C. Related Sections:
   1. Section 40 05 05, Exposed Piping Installation.

1.2 REFERENCES

A. Standards referenced in this Section are:
   1. AASHTO, Standard Specifications for Highway Bridges.
   2. ASTM D1784, Specification for Rigid Poly (Vinyl Chloride) (PVC) Compounds and Chlorinated Poly (Vinyl Chloride) (CPVC) Compounds.
   3. ASTM D1785, Specification for Poly (Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80 and 120.
   4. ASTM D2464, Specification for Threaded Poly (Vinyl Chlorinated) (PVC) Plastic Pipe Fittings, Schedule 80.
   5. ASTM D2466, Specification for Poly (Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 40.
   6. ASTM D2467, Specification for Poly (Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 80.
   7. ASTM D2513, Specification for Thermoplastic Gas Pressure Pipe, Tubing, and Fittings.
   8. ASTM D2564, Specification for Solvent Cements for Poly (Vinyl Chloride) (PVC) Plastic Piping Systems.
   9. ASTM D2665, Specification for Poly (Vinyl Chloride) (PVC) Plastic Drain, Waste, and Vent Pipe and Fittings.
   10. ASTM D683, Specification for Socket-Type Polyethylene Fittings for Outside Diameter-Controlled Polyethylene Pipe and Tubing.

11. ASTM D3034, Specification for Type PSM Poly (Vinyl Chloride) (PVC) Sewer Pipe and Fittings.
12. ASTM D3035, Specification for Polyethylene (PE) Plastic Pipe (DR-PR) Based on Controlled Outside Diameter.
13. ASTM D3139, Specification for Joints for Plastic Pressure Pipes Using Flexible Elastomeric Seals.
14. ASTM D3212, Specification for Joints for Drain and Sewer Plastic Pipes Using Flexible Elastomeric Seals.
15. ASTM D3222, Unmodified Poly (Vinylidene Fluoride) (PVDF) Molding Extrusion and Coating Materials.
16. ASTM D3261, Specification for Butt Heat Fusion Polyethylene (PE) Plastic Fittings for Polyethylene (PE) Plastic Pipe and Tubing.
17. ASTM D3311, Specification for Drain, Waste and Vent (DWV) Plastic Fittings Patterns.
18. ASTM D3350, Specification for Polyethylene Plastic Pipe and Fittings Materials.
19. ASTM D4101, Specification for Polypropylene Injection and Extrusion Materials.
20. ASTM F437, Specification for Threaded Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe Fittings, Schedule 80.
21. ASTM F438, Specification for Socket-Type Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe Fittings, Schedule 40.
22. ASTM F439, Specification for Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe Fittings, Schedule 80.
23. ASTM F441/F441M, Specification for Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe, Schedules 40 and 80.
24. ASTM F442/F442M, Specification for Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe (SDR-PR).
25. ASTM F477, Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe.
26. ASTM F656, Specification for Primers for Use in Solvent Cement Joints of Poly (Vinyl Chloride) (PVC) Plastic Pipe and Fittings.
27. ASTM F679, Specification for Poly (Vinyl Chloride) (PVC) Large-Diameter Plastic Gravity Sewer Pipe and Fittings.
28. ASTM F714, Specification for Polyethylene (PE) Plastic Pipe (SDR-PR) Based on Outside Diameter.
29. ASTM F1055, Specification for Electrofusion Type Polyethylene Fittings for Outside Diameter Controlled Polyethylene Pipe and Tubing.
30. ASTM F1336, Specification for Poly (Vinyl Chloride) (PVC) Gasketed Sewer Fittings.
31. ASTM F1674, Standard Test Method for Joint Restraint Products for Use with PVC Pipe.
32. ASTM F1760, Specification for Coextruded Poly (Vinyl Chloride) (PVC) Non-Pressure Plastic Pipe Having Reprocessed-Recycled Content.

33. AWWA C900, Polyvinyl Chloride (PVC) Pressure Pipe and Fabricated Fittings, 4 In.-12 In. (100 mm-300 mm), for Water Transmission and Distribution
34. AWWA C901, Polyethylene (PE) Pressure Pipe and Tubing, 1/2 In. (13 mm) Through 3 In. (76 mm), for Water Service.
35. AWWA C905, Polyvinyl Chloride (PVC) Pressure Pipe and Fabricated Fittings, 14 In.-48 In. (350 mm-1,200 mm).
36. AWWA C906, Polyethylene (PE) Pressure Pipe and Fittings, 4 In. (100 mm) Through 63 In. (1,600 mm), for Water Distribution and Transmission.
37. AWWA C907, Injection-Molded Polyvinyl Chloride (PVC) Pressure Fittings, 4 In. Through 12 In. (100 mm Through 300 mm).
38. NSF 14, Plastic Piping Systems Components and Related Material.
39. ANSI/NSF 61, Drinking Water System Components - Health Effects.
40. Standards of U.S. Food and Drug Administration.

1.3 QUALITY ASSURANCE

A. Qualifications:
   1. Manufacturer: Shall have a minimum of five years experience producing thermoplastic pipe and fittings substantively similar to the materials specified, and shall be able to submit documentation of satisfactory service in at least five completed installations in operation for at least five years each.
   2. Installer:
      a. Engage a single pipe installer who shall be responsible for all thermoplastic pipe Work, and who shall employ only tradesmen with specific skills and experience in the type of Work required.
      b. Installer shall have a minimum of five years experience installing thermoplastic pipe and fittings substantively similar to the materials specified and substantively similar to or larger than the scope of thermoplastic piping Work on the Project, and shall be able to submit documentation of satisfactory experience in at least five completed installations in operation for at least five years each.

B. Component Supply and Compatibility:
   1. Obtain all materials included in this Section, regardless of component Supplier, from a single thermoplastic pipe Supplier. All pipe of each material type shall be furnished by the same manufacturer.
   2. Thermoplastic pipe Supplier shall review and approve to prepare all Shop Drawings and other submittals for all materials furnished under this Section.
   3. Materials shall be suitable for specified service conditions and shall be integrated into overall assembly by thermoplastic pipe Supplier.

1.4 SUBMITTALS

A. Action Submittals: Submit the following:
   1. Shop Drawings:
      a. Submit piping layout Shop Drawings in accordance with Section 40 05 05, Exposed Piping Installation.
   2. Product Data:
      a. Submit product data on pipe, fittings, gaskets, hardware, and appurtenances sufficient to demonstrate compliance with the Contract Documents.

B. Informational Submittals: Submit the following:
   1. Certificates:
      a. Submit manufacturer's certificate of compliance standards referenced in this Section.
   2. Source Quality Control Submittals:
      a. When requested by ENGINEER, submit results of source quality control tests.
   3. Qualifications Statements:
      a. Submit qualifications of manufacturer when requested by ENGINEER.
      b. Submit qualifications of installer when requested by ENGINEER.

1.5 DELIVERY, STORAGE AND HANDLING

A. Refer to Section 40 05 05, Exposed Piping Installation.

PART 2 – PRODUCTS

2.1 SERVICE CONDITIONS

A. General:
   1. Pipe materials shall be suitable for services intended. Refer to piping schedules in Section 40 05 05, Exposed Piping Installation.
   2. Pipe shall be homogeneous throughout and free of visible cracks, holes, foreign inclusions, and other defects. Unless otherwise shown or indicated, pipe shall be uniform in color, opacity, density, and other physical properties.
   3. Comply with NSF 14.
   4. Buried pipe shall be capable of withstanding external live load, including impact, equal to AASHTO H-20 loading, with cover shown or indicated on the Drawings.
   5. Pipe, fittings, and appurtenances in contact with potable water or water that will be treated to become potable shall be listed in ANSI/NSF 61 as being suitable for contact with potable water, and shall comply with requirements of the authorities having jurisdiction at the Site.

2.2 POLYVINYL CHLORIDE (PVC) PIPING

A. PVC Pipe – General Applications: Unless otherwise shown or indicated, PVC pipe shall comply with the following:
   1. Manufacturers: Provide products of one of the following:
      a. Ipex, Inc.
      b. Spears Manufacturing Company.
      c. Or equal.
   2. Material: Unless otherwise specified, comply with the following:
      a. Type and Grade: Type 1, Grade 1.
      b. Wall Thickness: Schedule 80 complying with ASTM D1784 and ASTM D1785, and US Product Service PS 21-70 as having same outside diameter dimension as cast-iron pipe.
      c. Temperature Rating: Rated for temperature to 140 degrees F.
      d. Color: Gray.
   3. Fittings: Type, grade, schedule, and color of fitting shall match the associated pipe.
      a. Solvent Weld: Comply with ASTM D2467.
      b. Flanged: Provide flanged fittings with neoprene gaskets
   4. Joints:
      a. Solvent Weld: Use primer and solvent cement recommended by PVC pipe manufacturer for the application. Primer shall be in accordance with ASTM F656, and solvent cement shall be in accordance with ASTM D2564.
      b. Threaded: Use 100 percent virgin polytetrafluoroethylene (Teflon or PTFE) tape for threaded fittings. Pipe shall not be threaded.
      c. Flanged: Provide with backup flange minimum 1/8-inch thick. Backup flanges and connecting bolts shall be Type 304 stainless steel.

B. PVC Drain, Waste, and Vent (PVC-DWV) Pipe.
   1. Manufacturers: Provide products of one of the following:
      a. Chemtrol, manufactured by Nibco, Inc.
      b. Spears Manufacturing Company.
      c. Or equal.
   2. Material: In accordance with ASTM D1784. Unless otherwise shown or indicated, PVC-DWV pipe shall be:
      a. Type and Grade: Type 1, Grade 1.
      b. Wall Thickness: Schedule 40.
      c. Color: White.
   3. Fittings: Manufactured in accordance with ASTM D2665 and ASTM D3311.
      a. Solvent weld.
      b. Spigot.
   4. Joints:
      a. Solvent weld.
      b. Threaded.

C. Clear PVC Pipe (ARV Drain, Viewing Segment) – General Applications: Unless otherwise shown or indicated, PVC pipe shall comply with the following:
   1. Manufacturers: Provide products of one of the following:
      a. Ipex, Inc.
      b. Spears Manufacturing Company.
      c. Or equal.
   2. Material: Unless otherwise specified, comply with the following:
      a. Type and Grade: Type 1, Grade 1.
      b. Wall Thickness: Schedule 80 complying with ASTM D1784 and ASTM D1785, and US Product Service PS 21-70 as having same outside diameter dimension as cast-iron pipe.
      c. Temperature Rating: Rated for temperature to 140 degrees F.
      d. Color: Clear, Clear PVC shall comply with ASTM D1784 as Cell Classification of 12454-B.
   3. Fittings: Type, grade, schedule, and color of fitting shall match the associated pipe.
      a. Solvent Weld: Comply with ASTM D2467.
      b. Flanged: Provide flanged fittings with neoprene gaskets
   4. Joints:
      a. Solvent Weld: Use primer and solvent cement recommended by PVC pipe manufacturer for the application. Primer shall be in accordance with ASTM F656, and solvent cement shall be in accordance with ASTM D2564.
      b. Threaded: Use 100 percent virgin polytetrafluoroethylene (Teflon or PTFE) tape for threaded fittings. Pipe shall not be threaded.
      c. Flanged: Provide with backup flange minimum 1/8-inch thick. Backup flanges and connecting bolts shall be Type 304 stainless steel.

2.3 IDENTIFICATION

A. Pipe material identification requirements are in Section 40 05 05, Exposed Piping Installation.

2.8 SOURCE QUALITY CONTROL

A. Shop Tests:
   1. Pipe manufacturer shall maintain continuous quality control program.
   2. Where applicable and when requested by ENGINEER, submit results of source quality control tests specified in reference standards.
   3. CPVC plastic molding materials used for manufacturing pipe and fittings under this Section shall be tested for compliance with ASTM D1784.

PART 3 - EXECUTION

3.1 INSPECTION

A. Inspect pipe materials for defects in material and workmanship. Verify compatibility of pipe and fittings.

3.2 INSTALLATION

A. For exposed piping installation, refer to Section 40 05 05, Exposed Piping Installation.

+ + END OF SECTION + +

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SECTION 40 05 53

PROCESS VALVES

PART 1 - GENERAL

1.1 DESCRIPTION

A. Scope:
   1. CONTRACTOR shall provide all labor, materials, equipment, and incidentals as shown, specified, and required to furnish and install process valves, four-inch diameter and larger, and appurtenances, complete and operational.
   2. Valves for digester gas and air have been specifically identified. All other valves are for liquid service.

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

C. Related Sections:
   1. Section 05 05 33, Anchor Systems.
   2. Section 09 91 00, Painting.
   3. Section 40 05 05, Exposed Piping Installation.

D. The following index of this Section is included for convenience:

2.8 Painting of Exposed Valves, and Appurtenances

Part 3 - Execution
3.1 Inspection
3.2 Installation
3.3 Field Quality Control
3.4 Supplements

1.2 REFERENCES

A. Standards referenced in this Section are listed below:
1. American Bearing Manufacturers Association (ABMA).
2. ANSI B16.1, Cast-Iron Pipe Flanges and Flanged Fittings.
3. ANSI B16.34, Valves-Flanged, Threaded and Welding end. (ASME B16.34).
4. ANSI/NSF 61 Drinking Water Components – Health Effects.
5. API STD 594, Check Valves, Flanged Lug, Wafer and Butt-Welding.
6. API STD 598, Valve Inspection and Testing.
7. API STD 609, Butterfly Valves: Double Flanged, Lug-Type and Wafer-Type.
8. ASTM A126, Specification for Gray Iron Castings for Valves, Flanges and Pipe Fittings.
9. ASTM A193/A193M, Specification for Alloy-Steel and Stainless Steel Bolting Materials for High-Temperature Service.
10. ASTM A194/A194M, Specification for Carbon and Alloy Steel Nuts for Bolts for High Pressure and High Temperature Service, or Both.
11. ASTM A240/A240M, Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications.
12. ASTM A276, Specification for Stainless Steel Bars and Shapes.
13. ASTM A307, Specification for Carbon Steel Bolts and Studs, 60,000 psi Tensile Strength.
14. ASTM A351/A351M, Specification for Castings, Austenitic, Austenitic-Ferritic (Duplex), for Pressure-Containing Parts.
15. ASTM A380, Practice for Cleaning, Descaling and Passivation of Stainless Steel Parts, Equipment and Systems.
16. ASTM A536, Specification for Ductile Iron Castings.
17. ASTM A564/A564M, Specification for Hot-Rolled and Cold-Finished Age-Hardening Stainless Steel Bars and Shapes.
18. ASTM A743/A743 M, Specification for Castings, Iron-Chromium, Iron-Chromium-Nickel, Corrosion Resistant, for General Application.
21. ASTM B62, Specification for Composition Bronze or Ounce Metal Castings.
22. ASTM B98/B98M, Specification for Copper-Silicon Alloy Rod, Bar, and Shapes.

24. ASTM B138/B138M, Specification for Manganese Bronze Rod, Bar and Shapes.
25. ASTM B265, Specification for Titanium and Titanium Alloy Strip, Sheet and Plate.
26. ASTM B584, Specification for Copper Alloy Sand Castings for General Applications.
27. ASTM D429, Test Methods for Rubber Property - Adhesion to Rigid Substrates.
28. AWWA C500, Metal-Seated Gate Valves for Water Supply Service.
29. AWWA C501, Cast-Iron Sluice Gates.
30. AWWA C502, Dry-Barrel Fire Hydrants.
31. AWWA C504, Rubber-Seated Butterfly Valves.
32. AWWA C507, Ball Valves, 6-inch through 48-inch.
33. AWWA C508, Swing-Check Valves for Waterworks Service, 2-inch through 24-inch NPS.
34. AWWA C509, Resilient-Seated Gate Valves for Water Supply Service.
35. AWWA C540, Power-Actuating Devices for Valve and Slide Gates.
36. AWWA C550, Protective Interior Coatings for Valves and Hydrants.
37. AWWA Manual M49, Butterfly Valves: Torque, Head Loss, and Cavitation Analysis.
38. FS TT-C-494, Coating Compound, Bituminous, Solvent Type, Acid-Resistant.
39. NEMA MG 1, Motors and Generators.
40. ANSI/NSF 372, Drinking Water System Components – Lead Content.

1.3 QUALITY ASSURANCE

A. Manufacturer's Qualifications:
   1. Manufacturer shall have minimum of five years of experience producing substantially similar materials and equipment to that required and be able to provide evidence of at least five installations in satisfactory operation for at least five years.

B. Component Supply and Compatibility:
   1. Obtain each type of equipment and appurtenances included in this Section, regardless of the component manufacturer, from a single manufacturer of the type of process valve. For each type of valve, do not furnish valves of more than one manufacturer.
   2. Supplier of each type of equipment specified shall review and approve or prepare all Shop Drawings and other submittals for all components associated with the type of process valve Supplier is furnishing.
   3. Components shall be suitable for use in the specified service conditions. Components shall be integrated into the overall assembly by the process valve manufacturer.

1.4 SUBMITTALS

A. Action Submittals: Submit the following:
   1. Shop Drawings:
      a. Installation drawings showing orientation of valve in both plan and elevation view. Drawings shall clearly identify valve and its appurtenances, including controls, actuators, valve stems, and other components. Show dimensions of valves and appurtenances in relation to piping and structural and architectural components, where applicable.
      b. Controls for and control characteristics of modulating valves.
      c. Power and control wiring diagrams, including terminals numbers for electric-motor actuators.
      d. Calculations for sizing of electric actuators.
      e. Calculations for sizing of operating mechanism with extension stems.
      f. Calculations for sizing of gear actuators.
   2. Product Data:
      a. Product data sheets.
      b. Complete catalog information, including dimensions, weight, specifications, and identification of materials of construction of all parts.
      c. Corrosion resistance information to confirm suitability of valve materials for the application. Furnish information on chemical resistance of elastomers from elastomer manufacturer.
      d. Cv values and hydraulic headloss curves.
   3. Testing Plans:
      a. Submit plan for shop testing of each valve for which shop testing is specified, including testing plan's and test facility's limitations proposed.

B. Informational Submittals: Submit the following:
   1. Certificates:
      a. Certificates of compliance with referenced standards, where applicable, including those of AWWA, NSF, and others required by ENGINEER.
   2. Manufacturer Instructions:
      a. Submit manufacturer's instructions for handling, storing, and installing valves and appurtenances. Provide templates and setting drawings for valves and appurtenances that require anchor bolts or similar anchorages.
   4. Source Quality Control Submittals:
      a. Submit copies of shop test results and inspection data, certified by manufacturer.
   5. Field Quality Control Submittals:
      a. Submit results of field tests required.

6. Supplier's Reports:
   a. When requested by ENGINEER, submit written report of results of each visit to Site by Supplier's serviceman, including purpose and time of visit, tasks performed and results obtained.
7. Qualifications Statements:
   a. When requested by ENGINEER, submit manufacturer's qualifications demonstrating compliance with the Specifications, including list of existing installations with contact names and telephone number(s) for each.

C. Closeout Submittals: Submit the following:
   1. Operations and Maintenance Data:
      a. Furnish operation and maintenance manuals in accordance with Section 01 78 23, Operations and Maintenance Data.
      b. Furnish in operations and maintenance manuals complete nameplate data for each valve and electric actuator.

D. Maintenance Material Submittals: Submit the following:
   1. Spare Parts, Extra Stock Materials, and Tools:
      a. Spare Parts and Extra Stock Materials: Furnish as specified for each valve type.
      b. Tools: Furnish two sets of special tools (excluding metric tools, if applicable) for each size and type of valve furnished.

1.5 DELIVERY, STORAGE AND HANDLING

A. Packing, Shipping, Handling, and Unloading:
   1. Deliver materials and equipment to Site to ensure uninterrupted progress of the Work. Deliver anchorage products that are to be embedded in concrete in ample time to prevent delaying the Work.
   2. Inspect boxes, crates, and packages upon delivery to Site and notify ENGINEER in writing of loss or damage to materials and equipment. Promptly remedy loss and damage to new condition in accordance with manufacturer's instructions.
   3. Conform to Section 01 65 00, Product Delivery Requirements.

B. Storage and Protection:
   1. Keep products off ground using pallets, platforms, or other supports. Store equipment in covered storage and prevent condensation and damage by extreme temperatures. Store in accordance with manufacturer's recommendations. Protect steel, packaged materials, and electronics from corrosion and deterioration.
   2. Conform to Section 01 66 00, Product Storage and Handling Requirements.

PART 2 - PRODUCTS

2.1 GENERAL

A. Valves, General:
   1. Provide each valve with manufacturer's name and rated pressure cast in raised letters on valve body.
   2. Provide valves with brass or Type 316 stainless steel nameplate attached with Type 316 stainless steel screws. Nameplates shall have engraved letters displaying the following minimum information:
      a. Valve size.
      b. Pressure and temperature ratings.
      c. Application (other than water and wastewater).
      d. Date of manufacture.
      e. Manufacturer's name.
   3. Provide valves to turn clockwise to close, unless otherwise specified.
   4. Provide valves with permanent markings for direction to open.
   5. Manually operated valves, with or without extension stems, shall require not more than 40-pound pull on manual operator to open or close valve against specified criteria. Gear actuator and valve components shall be able to withstand minimum pull of 200 pounds on manual operator and input torque of 300-foot pounds to actuator nut. Manual operators include handwheel, chainwheel, crank, lever, and T-handle wrench.

B. Valve Materials:
   1. Valve materials shall be suitable for the associated valve's service or application, as shown.
   2. Protect wetted parts from galvanic corrosion caused by contact of different metals.
   3. Wetted components and wetted surfaces of valves used with potable water or water that will be treated to become potable shall conform to ANSI/NSF 61 and ANSI/NSF 372.
   4. Clean and descale fabricated stainless steel items in accordance with ASTM A380 and the following:
      a. Passivate all stainless steel welded fabricated items after manufacture by immersing in pickling solution of six percent nitric acid and three percent hydrofluoric acid. Temperature and detention time shall be sufficient for removing oxidation and ferrous contamination without etching surface. Perform complete neutralizing operation by immersing in trisodium phosphate rinse followed by clean water wash.
      b. Scrub welds with same pickling solution or pickling paste and clean with stainless steel wire brushes or by grinding with non-metallic abrasive tools to remove weld discoloration, and then neutralize and wash clean.

C. Valve Joints:
   1. Exposed Valves: Unless otherwise specified, provide with flanged ends conforming to ANSI B16.1. Pressure class of flanges shall be equal to or greater than specified pressure rating of the associated valve.
   2. For stainless steel bolting, except where nitrided nuts are required, use graphite-free anti-seize compound to prevent galling. Strength of joint shall not be affected by using anti-seize compound.

2.2 ROTOARY PUMP CONTROL VALVES

A. Manufacturers: Provide products of one of the following:
   1. GA Industries.
   2. Or equal.

B. General:
   1. Provide valves conforming to AWWA C507 Ball Valves for pump control applications and as specified herein. Valves shall consist of a main valve assembly and electro-hydraulic controls, completely assembled, tested and ready for field installation and wiring.
   2. Sizes: As shown on Valve Schedule.
   3. Rated Working Pressure: 150 psig.
   4. Maximum Fluid Temperature: 180 degrees F.
   5. Valve body shall have full, circular, unobstructed waterway and be trunnion-mounted, resilient seated. Stub Shafted valves will not be accepted.

C. Materials of Construction: Materials of construction shall conform to AWWA C507 and as follows:
   1. Body and Cover: Cast iron per ASTM A126 Class B with flanges faced and drilled to ANSI B16.1 Class 125. All internal parts shall be removable and serviceable without removing the valve body from the line. A flanged access cover shall be provided to permit resilient seat inspection, adjustment or replacement without valve disassembly or removal of inlet or outlet piping. The body and cover shall have replaceable bronze bearings to support the rotor (Ball) and hydraulic forces.
   2. Seating Surface on Ball: Type 316 Stainless Steel on the pump side.
   3. Ball: Ductile iron per ASTM A536 Gr 65-45-12 with two integrally cast, bronze bushed trunnions on the axis of rotation. The upper and lower trunnions shall be sealed by means of a removable O-ring seal cartridge. There shall be a single replaceable, hydraulically actuated rotor seat of Ultra High Molecular Wight Polyethylene (UHMWPE) or other suitable material, providing drop tight shutoff.
   4. Shaft: Type 316 stainless steel.
   5. Drive Mechanism: The drive mechanism shall be securely attached to the valve and keyed to the rotor shaft. Valves that incorporate pins to connect the drive shaft to the rotary ball will not be accepted. The drive mechanism shall have a ductile iron housing and an aluminum bronze crosshead

operating in a machined track. The mechanism shall convert the linear cylinder operator movement to a characterized rotation of the valve such that when closing, no less than 80% of the flow area is gradually cut off during the first 50% of the cylinder stroke. The remaining portion of the flow area shall be gradually reduced during the final 50% of the stroke.

6. Operator: The valve shall be operated by water fitted hydraulic cylinder meeting requirements of AWWA C507 and use water pressure obtained from the line. Cylinder tubes shall be stainless steel, honed to a 20 micro-inch finish with steel or ductile iron heads and a cast iron, steel or ductile iron piston, protected against corrosion by electro-plating, and a chrome plated stainless steel rod. Cylinder shall be equipped with a wiper ring to clean the piston rod before it enters the cylinder. Cylinder seals shall be Buna-N or other suitable material compatible with the fluid. Cylinder shall be sized to positively close the valve against full pump shutoff using the specified minimum water pressure. The cylinder shall be rigidly attached to the drive mechanism and shall not rotate or pivot. A device shall be provided to allow manual valve closure in the absence of hydraulic power.
7. Vent and drain connection for operation of the valve shall be provided.
8. Internal and external bolting and other hardware, including pins, set screws, studs, bolts, nuts, and washers shall be Type 316 stainless steel.

D. Controls:

1. Controls shall consist of a two-position four-way normal solenoid pilot with manual operator, independently adjustable normal opening and closing speed controls, emergency solenoid with separate, adjustable closing speed control, wye-strainer and isolating valves. Provide a limit switch for open and closed position, with a visual position indicator and a minimum of four sets of SPDT contracts mounted on the valve. Devices shall be furnished for 120VAC operation. Enclosures shall be NEMA 4 or 4X.
2. All controls and control piping shall be non-corrosive and suitable for the working pressure and electrical conditions.
3. Each valve shall be furnished with a high discharge pressure switch. Pressure switches shall piston actuated with adjustable differential. Sealed piston devices shall be provided to filter the piston assembly. Range shall be as required for the application. Range adjustment shall be accessible from the outside of the switch housing. Pressure switch housing and pistons shall be stainless steel. Diaphragms and o-ring seals shall be Viton. Retaining rings shall be Teflon. Switches shall have SPDT contact outputs which shall provide one N.O. and one N.C. contact rated 10A continuous at 120VAC. Switch housings shall be UL listed for NEMA 4, 4X, and 13 applications,

E. Testing:

1. Test each valve in manufacturer's shop in accordance with AWWA C507.

F. Interior Coating:

1. Valves shall be coated inside. Steel, cast-iron and ductile iron surfaces, except machined surfaces, shall be epoxy coated in accordance with AWWA C550.

2.3 BUTTERFLY VALVES

A. Manufacturers: Provide products of one of the following:
   1. DeZurik.
   2 Henry Pratt Company.
   3. Or equal.

B. General:
   1. Provide butterfly valves conforming to AWWA C504 and as specified herein.
   2. Sizes:
      a. Flanged: Four-inch through 72-inch diameter.
   3. Rated Working Pressure: 150 psig, Class 150B.
   4. Maximum Fluid Temperature: 150 degrees F.
   5. Valves shall provide drip-tight bi-directional shutoff at rated pressures.
   6. Mount valve seats in valve body. Rubber seats for 24-inch diameter and larger valves shall be replaceable in the field.
   7. Valves shall be capable of being maintained in open or partially open position for manual operation, and for automatic operation. When valve disc is maintained, there shall be no chatter or vibration of disc or operating mechanism.
   8. Valve packing shall be replaceable without dismantling valve.
   9. Disc shall provide uninterrupted 360-degree seat seal.

C. Materials of Construction: materials of construction shall conform to AWWA C504 and shall be as follows:
   1. Body: Cast-iron, ductile iron, or alloy cast-iron.
   2. Shaft: Type 316 stainless steel.
   3. Discs:
      a. Valves Smaller than 30-inch Diameter: Cast-iron.
      b. Valves 30-inch Diameter and Larger: Ductile iron.
   4. Seats: Buna-N or other synthetic rubber suitable for the application.
   5. Seating Surfaces: Type 316 stainless steel.
   6. Bearings:
      a. Valves Smaller than 24-inch Diameter: Nylon.
      b. Valves 24-inch Diameter and Larger: Fiberglass with Teflon lining.
   7. Shaft Seals: Externally adjustable, material same as for seats. For services that are either buried or submerged, self-adjusting V-type chevron, material same as for seats.
   8. Tapered Pins for Attachment of Shaft to Disc: Type 316 stainless steel.
   9. Internal and external bolting and other hardware; including pins, set screws, studs, bolts, nuts, and washers shall be Type 316 stainless steel.

D. Interior Coating:
   1. Valves shall be coated inside. Steel, cast-iron, and ductile iron surfaces, except machined surfaces, shall be epoxy-coated in accordance with AWWA C550.

E. Testing:
   1. Test each valve in the manufacturer's shop in accordance with AWWA C504.

F. Gear Actuators for Manual Valves:
   1. Provide gear actuators conforming to AWWA C540.
   2. Gear actuators for valves 20-inch diameter and smaller shall be constructed for 150 psi differential pressure and 16 feet per second port velocity.

2.4 AIR RELEASE VALVES

A. Manufacturers: Provide products of one of the following:
   1. Val-Matic.
   2 GA Industries.
   3. Or equal.

B. General:
   1. Provide air release valves intended for well and clean water vertical turbine pump service and manufactured and tested in accordance with AWWA C512 and as specified herein.
   2. Sizes:
      a. Flanged: See valve schedule.
      b. Valves 4-inch and larger shall have bolted flange inlets equal to the valve size. Flanges shall be in accordance with ANSI B16.1 for Class 125 iron flanges.
      c. The valves shall have two additional NPT connections for the addition of air release valves, gauges, testing, and draining.
   3. Rated Working Pressure: 150 psig.
   4. Design:
      a. Air release valves shall be fully automatic float operated valves designed to exhaust air which is present in the pump column on pump startup and allow air to re-enter the column on pump shutdown or should a negative pressure occur. A dual port throttling device shall provide adjustable control of the exhaust rate and allow free flow into the valve through a separate inlet port. A regulated exhaust device shall allow free air flow in and out of the valve, close upon rapid air exchange, and control the air exhaust rate to reduce pressure surges.

b. The valve body shall provide a through flow area equal to the nominal valve size. A bolted cover with allow screws and flat gasket shall be provided to allow for maintenance and repair.
c. Floats shall be unconditionally guaranteed against failure including pressure surges.
d. The resilient seat shall provide drop tight shut off to the full valve pressure rating.
e. Valve interiors and exteriors shall be coated with an NSF/ANSI 61 certified fusion bonded epoxy in accordance with AWWA C550 when specified.

5. Materials:
   a. Body and Cover: Cast Iron.
   b. Float, Guide Shaft and Bushings: Stainless Steel.
   c. Disc and Seat: Bronze.

2.5 APPURTENANCES FOR EXPOSED METALLIC VALVES

A. General:
   1. For valves located less than five feet above operating floor, provide levers on four-inch diameter quarter-turn valves, and provide handwheels on all other valves, unless otherwise shown or specified.
   2. For valves located five feet or more above operating floor, provide chain operators.
   3. Where indicated, provide extension stems and floorstands.

B. Handwheels:
   1. Conform to applicable AWWA standards.
   2. Material of Construction: Ductile iron, or cast aluminum.
   3. Arrow indicating direction of opening and word "OPEN" shall be cast on trim of handwheel.
   4. Maximum Handwheel Diameter: 2.5 feet.

C. Chain Operators:
   1. Chains shall extend to three feet above operating floor.
   2. Provide 1/2-inch stainless steel hook bolt to keep chain out of walking area.
      a. Chain: Type 316L stainless steel.
      b. Chainwheel: Recessed groove type made out of Type 316 stainless steel.
      c. Guards and Guides: Type 316L stainless steel.
   4. Chain Construction:
      a. Chain shall be of welded link type with smooth finish. Chain that is crimped or has links with exposed ends is unacceptable.
   5. Provide geared operators where required to position chainwheels in vertical position.

D. Crank Operator:
   1. Crank operator shall be removable and fitted with rotating handle.
   2. Maximum Radius of Crank: 15 inches.
   3. Materials:
      a. Crank: Cast-iron or ductile iron.
      b. Handle: Type 304 stainless steel.
      c. Hardware: Type 304 stainless steel.

2.6 TOOLS, LUBRICANTS, AND SPARE PARTS

A. Lubricants: For valves, actuators, and appurtenances requiring lubricants, provide suitable lubricants for initial operation and for first year of use following Substantial Completion. Lubricants for equipment associated with conveying potable water or water that will be treated to become potable shall be food-grade and ANSI/NSF 61-listed.

B. Tools, spare parts, and maintenance materials shall conform with Section 01 78 43, Spare Parts and Extra Materials.

2.7 PAINTING OF EXPOSED VALVES, AND APPURTENANCES

A. Exterior steel, cast-iron, and ductile iron surfaces, except machined surfaces of exposed valves and appurtenances, shall be finish painted in manufacturer's shop. Surface preparation, priming, finish painting, and field touch-up painting shall conform to Section 09 91 00, Painting.

PART 3 - EXECUTION

3.1 INSPECTION

A. Examine conditions under which materials and equipment are to be installed and notify ENGINEER in writing of conditions detrimental to proper and timely completion of the Work. Do not proceed with the Work until unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. General:
   1. Install valves and appurtenances in accordance with:
      a. Supplier's instructions and the Contract Documents.
      b. Requirements of applicable AWWA standards.
      c. Applicable requirements of Section 40 05 05, Exposed Piping Installation.
   2. Install valves plumb and level. Install all valves to be free from distortion and strain caused by misaligned piping, equipment, and other causes.

3. Position swing check valves and butterfly valves so that, when valve is fully open, valve disc does not conflict with piping system elements upstream and downstream of valve.

B. Exposed Valves:
   1. Provide supports for large or heavy valves and appurtenances as shown or required to prevent strain on adjoining piping.
   2. Operators:
      a. Install valves so that operating hand wheels or levers can be conveniently turned from operating floor without interfering with access to other valves, piping, structure, and equipment, and as approved by ENGINEER.
      b. Avoid placing operators at angles to floors or walls.
      c. Orient chain operators out of way of walking areas.
      d. Install valves so that indicator arrows are visible from floor level.
      e. For motor-operated valves located lower than five feet above operating floor, orient motor actuator to allow convenient access to pushbuttons and hand wheel.
   3. Floor Stands and Stems:
      a. Install floor stands as shown and as recommended by manufacturer.
      b. Provide lateral restraints for extension bonnets and extension stems as shown and as recommended by manufacturer.
      c. Provide sleeves where operating stems pass through floor. Extend sleeves two inches above floor.

3.3 FIELD QUALITY CONTROL

A. Field Tests:
   1. Adjust all parts and components as required to provide correct operation of valves.
   2. Conduct functional field test on each valve in presence of ENGINEER to demonstrate that each valve operates correctly.
   3. Verify satisfactory operation and controls of motor operated valves.
   4. Demonstrate satisfactory opening and closing of valves at specified criteria requiring not more than 40 pounds effort on manual actuators.
   5. Test ten percent of valves of each type by applying 200 pounds effort on manual operators. There shall be no damage to gear actuator or valve.

B. Supplier's Services:
   1. Provide services of qualified factory-trained service technicians to check and approve installation of the following types of valves:
      a. Rotary Pump Control Valves.
   2. Supplier's serviceman shall perform the following:
      a. Instruct CONTRACTOR in installing equipment.
      b. Supervise installation of equipment.

c. Inspect and adjust equipment after installation and ensure proper operation.
d. Instruct OWNER's personnel in operating and maintaining the equipment.

3. Manufacturer's representative shall make a minimum of 1 visit, with a minimum of 8 hours onsite for each visit. First visit shall be for unloading supervision (if specified) and instruction of CONTRACTOR in installing equipment; second visit shall be for assistance in installing equipment; third visit shall be for checking completed installation and start-up of system; fourth visit shall be to instruct operations and maintenance personnel. Representative shall revisit the Site as often as necessary until installation is acceptable.
4. Training: Furnish services of Supplier's qualified factory trained specialists to instruct OWNER's operations and maintenance personnel in recommended operation and maintenance of equipment. Training requirements, duration of instruction and qualifications shall be in accordance with Section 01 79 23, Instruction of Operations and Maintenance Personnel.
5. All costs, including expenses for travel, lodging, meals and incidentals, and cost of travel time, for visits to the Site shall be included in the Contract Price.

3.4 SUPPLEMENTS

A. The supplements listed below, following "End of Section" designation, are a part of this Specification Section:
   1. Table 40 05 53-A, Schedule of Valves

+ + END OF SECTION + +

TABLE 40 05 53-A, SCHEDULE OF VALVES WITH ELECTRIC ACTUATORS

Valve Number	Location	Service	Valve Size (in)	Operator	Specification Paragraph	Remarks
ARV-1		FW	4	--	2.4	--
BFV-1		FW	20	Manual	2.3	Provide Hand Wheel Operator
BFV-2		FW	20	Manual	2.3	Provide Hand Wheel Operator
RPCV-1		FW	14	Hydraulic Cylinder	2.2	Provide ANSI Class 125 Flanges
RPCV-2		FW	14	Hydraulic Cylinder	2.2	Provide ANSI Class 125 Flanges
RPCV-3		FW	14	Hydraulic Cylinder	2.2	Provide ANSI Class 125 Flanges

The following abbreviations are used in Table 40 05 53-A.

A. Valve Type Abbreviations

Valve Type	Abbrev		Valve Type	Abbrev.
Metal-seated Gate Valve	GV-MS		Swing Check Valve	SCV
Resilient-seated Gate Valve	GV-RS		Automatic Pressure-reducing Valve	PRV
Eccentric Plug Valve	PV		Automatic Pressure-sustaining Valve	PSV
Eccentric Plug Valve (digester gas service)	PV-DI		Automatic Electric Check Valve	ECV
Rotary Pump Control Valve	RPCV		Check Valve (air service)	CV-AS
Butterfly Valve	BV		Check Valve (digester gas service)	CV-DI
Butterfly Valve (air service, open-close applications)	BV-AS		Telescopic Valve	TEL
High-performance Butterfly Valve (air service, modulating)	HBV-AS		Mud Valve	MUD
Butterfly Valve (digester gas service, open-close applications)	BV-DI		Fire Hydrant	HYD
High-performance Butterfly Valve (digester gas service, modulating)	HBV-DI			

B. Service Abbreviations

Service	Abbrev		Service	Abbrev.
Sanitary Sewer	SAN		Wastewater	WW
Storm Sewer	ST		Overflow	OF
Combined Sewer	CS		Centrate	CEN
Sanitary Force Main	SFM		Filtrate	FILT
Raw Water	RW		Scum	SCUM
Potable Water	PW		Primary Sludge	PS
City Water	CW		Return Activated Sludge	RAS
Non-Potable Water	NPW		Waste Activate Sludge	WAS
Plant Effluent Water	PEW		Thickened Sludge	TS
Spray Water	SPW		Mixed Sludge	MS
Backwash Water	BW		Digested Sludge	DS
Hot Water Supply	HWS		Chlorine Solution	CLS
Hot Water Return	HWR		Sodium Hydroxide	NAOH
Influent	INF		Sodium Hypochlorite	NAOCL
Effluent	EFF		Polymer Solution	POLYS
Drain	DR		Alum	AL
Process Air	PA		Hydraulic Fluid	HF
Instrument Air	IA		Fuel Oil	FO
Digester Gas	DIG		Lube Oil	LO
Chlorine Gas	CLG		Finished Water	FW

SECTION 43 21 40

VERTICAL TURBINE PUMPS

PART 1 - GENERAL

1.1 DESCRIPTION

A. Scope:
   1. CONTRACTOR shall provide all labor, materials, tools and equipment required to furnish and install vertical turbine pumps complete and operational with motors, accessories, and services as shown and as specified.

B. Coordination:
   1. Review installation procedures under this and other Sections and coordinate the installation of items that must be installed with, or before the vertical turbine pump Work.

C. Related Sections:
   1. Section 03 00 05, Concrete
   2. Section 05 05 33, Anchor Systems.
   3. Section 09 91 00, Painting.
   4. Division 26, Electrical
   5 Division 40, Applicable Sections on Instrumentation and Controls.
   6. Division 40, Applicable Sections on Piping, Valves and Appurtenances.

1.2 REFERENCES

A. Standards referenced in this Section are listed below:
   1. American Bearing Manufacturers Association, (ABMA).
   2. American National Standards Institute, (ANSI).
      a. ANSI B16.1, Cast-Iron Pipe Flanges and Flanged Fittings.
   3. American Society for Testing and Materials, (ASTM).
      a. ASTM A 48/A 48M, Specification for Gray Iron Castings.
      b. ASTM A 582/A 582M, Specification for Free-Machining Stainless Steel Bars.
   4. American Water Works Association, (AWWA).
   5. Hydraulics Institute, (HI).
   6. Institute of Electrical and Electronics Engineers, (IEEE).
   7. National Electrical Code, (NEC).
   8. National Electrical Manufacturers' Association, (NEMA).
   9. National Sanitation Foundation, (NSF).
   10. The Society for Protective Coatings, (SSPC).
      a. SSPC SP 10, Near-White Blast Cleaning.
   11. Local and state building codes and ordinances.

1.3 QUALITY ASSURANCE

A. Manufacturer's Qualifications:
   1. Manufacturer shall have a minimum of five years experience producing substantially similar equipment and shall be able to show evidence of at least five installations in satisfactory operation for at least five years.

B. Component Supply and Compatibility:
   1. Obtain all equipment included in this Section regardless of the component manufacturer from a single pump manufacturer.
   2. The pump equipment manufacturer is to review and approve or is to prepare all Shop Drawings and other submittals for all components furnished under this Section.
   3. All components shall be specifically constructed for the specified service conditions and shall be integrated into the overall assembly by the vertical turbine pump equipment manufacturer.

1.4 SUBMITTALS

A. Shop Drawings: Submit the following:
   1. Shop Drawings Showing: Fabrication, assembly, installation, and wiring diagrams.
   2. Descriptive literature including cross-sectional views of the pumps indicating the materials of construction and preliminary dimension prints of pumps and motors.
   3. Performance curves for the complete pump assemblies showing the relationship between head and capacity, efficiency, brake and motor horsepower, and NPSH from shut-off head to the minimum operating head specified. Curves shall be corrected for pump losses and shaft friction horsepower losses. Pump losses shall include column and discharge head losses.
   4. Impeller type.
   5. Bowl and shaft WR square.
   6. Maximum down thrust at design points and shutoff, and maximum up thrust.
   7. Weight of pumps and motors (including all components).
   8. Motor manufacturer, type, enclosure, phase, voltage, rated horsepower, full load and locked rotor amperage, temperature rating, and expected minimum life under design conditions, minimum efficiency at 1/2, 3/4 and full load, and descriptive literature including description of motor insulation, for each type of motor to be furnished.
   9. A list of deviations from the Contract Documents.
   10. Names and addresses of the nearest factory authorized service organization.
   11. Ten copies of certified shop tests.
   12. Copy of paint certification.

B. Operation and Maintenance Manuals:
   1. Submit complete Installation, Operation and Maintenance Manuals, including, test reports, maintenance data and schedules, description of operation, and spare parts information.
   2. Furnish Operation and Maintenance Manuals in conformance with the requirements of Section 01 78 23, Operation and Maintenance Data.

C. Certificates:
   1. Submit certificate stating that Vertical Turbine Pump Manufacturer has coordinated with VFD Manufacturer to insure that VFD will function properly with driven piece of equipment.

1.5 PRODUCT 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.

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.

C. Acceptance at Site:
   1. All boxes, crates and packages shall be inspected by CONTRACTOR upon delivery to the Site. CONTRACTOR shall notify ENGINEER, in writing, if any loss or damage exists to equipment or components. Replace loss and repair damage to new condition in accordance with manufacturer's instructions.

PART 2 - PRODUCTS

2.1 EQUIPMENT PERFORMANCE

A. General:
   1. Pumps shall be vertical turbine type, and designed for the performance and design requirements as required, at maximum speed unless otherwise noted. Pumps shall be suitable for pumping of finished potable water.

B. Design Criteria:
   1. Pumps shall be specially designed, constructed, and installed for the service specified and shall comply with the following minimum conditions:

Design Conditions	**Pump ID**			
ID:	Pump No. 1	Pump No. 3	Pump No. 5	Pump No. 6
Design Flow, (gpm):	8,750	5,600	7,700	8,750
*Design TDH, (ft.):	145	375	372	145
Shutoff Head, (ft.):	310	630	640	303
Minimum Bowl Efficiency at Design, (percent):	84.5	82.0	83.0	84.5
Motor, (Hp):	450	700	900	450
Maximum Operating Speed, (rpm):	1,200	1,200	1,200	1,200
Pump Column Diameter, (in.):	20	20	20	20
Discharge Size, (in.):	20	20	20	20
Low flow at 2nd Design Point, (gpm):	4,000	4,000	4,000	4,000
TDH at 2nd Design Point, (ft.):	250	480	480	250
**Approximate Pump Discharge Center-line Elevation, (ft.):	523.17	523.17	526.17	526.17
Liquid Pumped:	Finished Water	Finished Water	Finished Water	Finished Water
Temperature, (°F):	50-75	50-75	50-75	50-75
Drive Type***:	Motor	Motor	Variable Frequency Drive	Variable Frequency Drive
Motor: Volts/Phase/Hertz	2,300/3/60	2,300/3/60	2,300/3/60	2,300/3/60
Pump Basis of Design Manufacturer/Model	Goulds/ 20 GHC 3 Stage	Floway/ 24 MKM/N 4 stage	Floway/ 24 MKM/N 4 stage	Goulds/ 20 GHC 3 Stage
Pump Type:	CAN	VTP	VTP	CAN

* Does not includes entrance, pump, column, and discharge head losses.

** CONTRACTOR shall field verify existing pump discharge center-line elevation.

*** VFD's shall be programmed and configured by VFD Manufacturer together with the pump manufacturer and pump control valve manufacturer.

2.2 MANUFACTURERS

A. Manufacturer (Pump No. 1 and No. 6):
   1. Goulds
   2. Or Equal

B. Manufacturer (Pump No. 3 and No 5):
   1. Floway
   2. Or Equal

2.3 DETAILS OF CONSTRUCTION (PUMP NO. 1 AND NO. 6)

A. Pump Materials and Construction:
   1. Pump Bowl Assembly:
      a. The pump bowls shall be lined with fusion bonded epoxy lined type to reduce friction. The waterway and diffusion vanes shall be smooth and free from nodules, bumps and dips, and shall be cast of high quality free of blow holes, sand holes and other detrimental defects. The bowls shall be accurately machined and fitted with a suction bell with integral cast ribs supporting the suction bearing. The bearings shall be sleeve type and are to be lubricated by the product being pumped. The bearings are to be located above and below each impeller. The suction bearing shall be permanently packed with food grade grease, and shall have a length not less than 2 times the shaft diameter. The bowls are to be flanged with machined rabbet fit connections
      b. Fit the bowls and suction bell with renewable wear ring(s) adjacent to the impeller skirts. Wear ring clearances shall not exceed 0.002-inch clearance per inch of diameter.
      c. The impellers shall be cast in one piece of the enclosed type. The impellers shall be statically and dynamically balanced. Unless otherwise stipulated, if the bowl diameter is smaller than 22-inch diameter the impeller shall be securely fastened to the shaft with taper split bushings (collets). Impellers with bowl diameters larger than 22" shall be double keyed. Impellers shall be adjusted vertically by external means and shall have sufficient axial clearance for reliable service in accordance with the specified operating conditions.
   2. Pump Column Assembly:
      a. The column pipe shall be flanged with rabbeted fits to ensure proper alignment. It shall be constructed of material conforming to ASTM A53 Gr. B steel. The weight of the column pipe shall be no less than that stated in ANSI/AWWA Specification E101. The column size shall be such that friction loss will not exceed 5' per 100', based on the rated capacity of the pump. Column length shall not exceed 10' for 1800 RPM and 5' lengths for pumps running at 3,600 RPM. The top and bottom section shall not exceed 5'.
      b. The column line shaft shall be turned and ground. They shall be furnished in interchangeable sections not over 10 feet in length. The

butting faces shall be machined square to the axis of the shaft with maximum permissible misalignment of the thread axis with the shaft axis 0.002 in 6". The size of the shaft shall be no less than that determined by ANSI/AWWA-E101 Specifications, Section 5.5 and shall be such that elongation due to hydraulic thrust will not exceed the axial clearance of the impellers in the pump bowls. Maximum run out shall not exceed 0.005" in 10 feet. The line shafts shall be provided with 304 stainless steel sleeves at the location of each line shaft bearing. The line shaft bearings shall be sleeve type. Line shaft bearing spacing shall be such that shaft first critical frequency shall be safely above or below the operating frequency.

c. Threaded shaft couplings are to be supplied for shafts less than 2-3/4" diameter and shall be sized per ANSI/AWWA E101 section A-4.1.4. They shall utilize left-hand threads to tighten during operation.
d. Bearing retainers shall be of the drop-in type, held in place by compression of the butted ends of the column pipe.

3. Discharge Head:
   a. The discharge head shall be fabricated of carbon steel materials using ASTM A181 flanges, ASTM A53 Grade B body pipe and ASTM A516 steel plate with suction and discharge flanges in-line with each other and located 180 apart. Discharge head design shall be capable of containing maximum pressure developed by pump plus suction pressure. The suction flange shall be 150# ANSI raised face with bolt holes straddling suction centerline. The discharge flange shall be 150# ANSI raised face with bolt holes straddling the vertical centerline. A 1/4" NPT pressure gauge connection shall be supplied on the top centerline of the suction and discharge outlets. A 3/4" NPT barrel vent tap shall be located on the outer casing of the discharge head. The top of the discharge head shall be machined to accept a standard NEMA P base driver and have a diameter equal to the driver base diameter. The base flange shall be machined, drilled and gasketed to provide a pressure containing seal to the top of the suction barrel. The head shaft shall be connected to the top line shaft beneath the motor to facilitate ease of assembly and maintenance. All couplings and other moving or rotating parts shall be covered on all sides by an OSHA approved coupling guard. Coupling guards shall be fabricated from 16 USS gage or thicker galvanized or aluminum-clad steel or from 1/2 inch mesh expanded metal. Each guard shall be designed for easy installation and removal. All necessary supports and accessories shall be provided for each guard. The pump shall be furnished with a stainless steel nameplate securely mounted to the discharge head. At a minimum it shall contain information providing (design flow, design TDH, HP, RPM, bowl model number, number of stages, manufacturer serial number, pump type, impeller setting dimension).
   b. A rigid flanged adjustable "spacer" type coupling shall be provided to couple the motor shaft to the pump shaft. The spacer shall be of sufficient length to allow the mechanical seal to be removed without

disturbing the motor. This coupling shall allow for the vertical adjustment of the shaft mounted impellers.

c. The discharge head shall be fitted with a mechanical seal. The seal shall be of the split type, easily replaceable and have its face continuously flushed with the product being pumped. The seal shall be equivalent to the Chesterton 442.

4. Barrels:
   a. For barrel (can type) pumps, each pump barrel shall be of the ANSI/HI-9.8 Length design and size recommended by the manufacturer and shall conform to Hydraulic Institute Standards. Barrel inlet nozzle and flange shall be located and sized properly per ANSI/HI9.8 Standard. Pump barrel (can) must be designed in such a manner as to prevent submerged vortices from being developed. The barrel's square top mounting plate shall be of sufficient thickness to drill and tap for ANSI rated flange bolting to match the base flange of the discharge head. The top mounting plate of the barrel shall be properly machined and be gasketed or "O" ringed for zero leakage connection to the discharge head. The pressure rating of the barrel shall be capable of containing the maximum suction pressure. The pumping system shall be designed to be supported from the base of the can.
   b. The suction barrel shall be fitted with 2 direction vanes to reduce hydraulic swirling. They should be welded to the inside of the barrel in line with the suction centerline and located 180 degrees apart.
   c. The bottom of the barrel shall contain 2 direction vanes welded in a cross patter perpendicular to one another to help minimize hydraulic swirling.
5. Materials of Construction:
   a. Pump Bowls: Cast Iron (ASTM A48 c130, Enamel Lined).
   b. Impellers: 952 Bronze – (ASTM B584-90b Alloy 952).
   c. Bowl Assembly Shaft – 416 Stainless Steel (ASTM A582088a Type 416).
   d. Bowl Bearings: Bronze – (ASTM B505-91 Alloy 932).
   e. Bowl Bolting: 304 Stainless Steel (ASTM f593 Gr CW1).
   f. Bowl Wear Rings: Bronze – (ASTM B148-89a Alloy 954).
   g. Column Pipe Thickness: Schedule 40.
   h. Column Bolting: 304 Stainless Steel (ASTM f593 Gr CW1).
   i. Line Shaft: 416 Stainless Steel (ASTM A582-88a).
   j. Line Shaft Couplings: 416 Stainless Steel (ASTM A582-88a).
   k. Line Shaft Sleeves: 304 Stainless Steel.
   l. Line Shaft Bearings: Styrene Butadiene Rubber (SBR).
   m. Bearing Retainers: Ductile Iron – (ASTM A536-84 Gr 60-40-18).
   n. Discharge Head: Fabricated Steel – (A516-Gr 70 plt, A105 flg, A53-Gr B pipe).
   o. Name Plate: Stainless Steel.

B. Motor Type: As required to drive the pump specified above. Motors shall meet

the requirements of Section 26 29 01, Motors. Motor shall be VFD rated for Pump No. 6 and meet the requirements of NEMA MG-1, Part 31.

2.4 DETAILS OF CONSTRUCTION (PUMP NO. 3 AND NO. 5)

A. Pump Materials and Construction:

1. Pump Bowl Assembly: The bowls shall be flanged type constructed of close grained cast iron conform to ASTM A48, class 30. They shall be free from sand holes, blowholes, or other faults and must be accurately machined and fitted to close tolerances. They shall be capable of withstanding a hydrostatic pressure equal to twice the pressure at rated flow or 1.5 times shut-off head, whichever is greater. The intermediate bowls shall have enamel or epoxy lined waterways for maximum efficiency and wear protection. All the bowls shall be fitted with sleeve type bearings of bronze alloy C89835.
2. Impellers: The impellers shall be constructed from ASTM B584 Silicon Bronze and shall be the enclosed type. They shall be free from defects and must be accurately cast, machined and filed for optimum performance and minimum vibration. Impellers shall be balanced to grade G6.3 of ISO 1940 as minimum. They shall be securely fastened to the bowl shaft with taper locks of 416 stainless steel or key and split thrust ring of stainless steel.
3. Suction: The suction bowl or suction bell shall be provided with a non-soluble grease packed bronze bearing. A bronze sand collar shall be provided to protect this bearing from abrasives in the pumping fluid. The bearing housing shall have sufficient opening at the bottom for easy removal of the bearing.
4. Shaft: The bowl shaft shall be constructed from ASTM 582 type 416 stainless steel. It shall be precision ground and polished with surface finish better than 40 RMS.
5. Column Assembly:
   a. Column Pipe: The column pipe shall be furnished in sections not exceeding a nominal length of 10 ft. and shall be connected by flanges. The length of the top and bottom sections shall not be more than 5 ft. The pipes shall be of ASTM A53 grade B steel pipe and the weight shall be not less than schedule 30. The end of the pipe shall be with 8 threads per inch with 3/16-in taper per foot thread and faced parallel to butt against the centering spiders of ASTM B584 Silicon Bronze to form accurate alignment. All column flange faces shall be parallel and machined for rabbet fit to permit accurate alignment. The inside diameter of the pipe shall be such that the head losses shall not be more than 5 feet per 100 feet of pipe or the flow velocity not to exceed 3 ft/sec based on rated flow of the pump.
   b. Lineshaft: The lineshaft shall be of ASTM A582 type 416 stainless steel ground and polished with surface finish not to exceed 40 RMS. They shall be furnished in interchangeable section not over ten feet in length, and shall be coupled with threaded stainless steel couplings (up to 2-15/16" diameter) machined from solid steel bar. It shall have left-hand thread to tighten during pump operation. The diameter of the shaft and

coupling shall be designed in according with AWWA E101 Standard.

c. Bearing: Bearing shall be fluted rubber retained in the centering spider by a shoulder on each end of the bearing.

6. Discharge Head Assembly:
   a. Discharge Head: It shall be of the high profile type to all shaft coupled above stuffing box and provided for mounting the driver and support the column and bowl assemblies. It shall be of high-grade cast iron, ASTM A48 Class 30. The above ground outlet shall be flanged to match ANSI Class 125 (for cast iron). It shall have a 1/2-inch NPT connection for a pressure gauge.
   b. Stuffing Box: The stuffing box shall be cast iron and be fitted with a mechanical seal. The seal shall be of the split type, easily replaceable and have its face continuously flushed with the product being pumped. The seal shall be equivalent to the Chesterton 442.

B. Motor Type: As required to drive the pump specified above. Motors shall meet the requirements of Section 26 29 01, Motors. Motor shall be VFD rated for Pump No. 5 and meet the requirements of NEMA MG-1, Part 31.

2.5 SURFACE PREPARATION AND SHOP PAINTING

A. Pumps, motor, drive and appurtenances shall receive shop primer and shop finish coating conforming to requirements of Section 09 91 00, Painting.

B. Surface preparation and painting shall conform to the requirements of Section 09 91 00, Painting. The interior surfaces of the pump, suction bell and discharge column pipes, and the interior surfaces of the pump head and suction barrel shall be cleaned with a Near White Metal Sandblast (SSPC SP 10), shall receive two coats of a NSF 61 approved coating with a minimum dry film thickness of 8 mils applied in accordance with the paint manufacturers printed instructions.

C. All gears, bearing surfaces, machined surfaces and other surfaces which are to remain unpainted shall receive a heavy application of grease or other rust-resistant coating. This coating shall be maintained during storage and until the equipment is placed into operation.

D. CONTRACTOR shall certify, in writing, that the shop primer and shop finish coating system conforms to the requirements of Section 09 91 00, Painting.

2.6 SOURCE QUALITY CONTROL

A. Shop Tests:
   1. Pump columns and discharge heads shall be hydrostatically tested to twice the discharge head or one and a half times the shutoff head, whichever is greater.
   2. Running Test: Pump assembly shall be operated from zero to maximum capacity as shown on the approved curve. Results of the test shall be shown in a plot of test curves showing head, flow, horsepower, overall efficiency and

current. Readings shall be taken at a minimum of five evenly spaced capacity points including shutoff, design point and minimum head for which pump is designed to operate. Where variable speed units are specified, curves shall have at least five speeds plotted between maximum and minimum rpm.

3. All tests shall be witnessed by a Registered Professional Engineer, who may be an employee of the manufacturer. The Registered Professional Engineer shall sign and seal all copies of test curves and shall certify that hydrostatic tests were performed. The State of registration, registration number and the name on the seal shall be clearly legible. Conduct tests in conformance with the methods described in Section A6 of AWWA E101. The serial numbers of the pumps shall be on the test curves and hydrostatic tests.
4. Pumps shall not be shipped until the ENGINEER has approved the test reports.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Installation shall be in complete accordance with manufacturer's instructions and recommendations and the approved Shop Drawings.

B. Pumping units shall be installed on concrete bases and grouted as shown.

C. Installation shall include furnishing and applying an initial supply of grease and oil, recommended by the manufacturer.

D. Support piping independent of pump.

E. Check and align pump, motor and shafting.

3.2 START-UP AND TEST

A. CONTRACTOR shall verify that structures, pipes and equipment are compatible.

B. Make adjustments required to place system in proper operating condition.

C. Field Vibration Tests:
   1. Vibration measurements shall be made at the upper motor bearing of pump while operating over its speed range. Measurements shall be made in each of two orthogonal horizontal directions one of which shall be in the plane of the greatest vibration and in the vertical (pump axial) direction. Measured levels in the horizontal direction of the operating pump shall not exceed those in the Hydraulic Institute Standards, latest edition.
   2. CONTRACTOR shall provide the services of an Engineer to conduct the vibration tests after the installation has been completed. The Engineer shall be recognized as an expert in the field of vibration analysis and control and shall have qualifications acceptable to ENGINEER.

3. Submit certified report of successful vibration tests for approval.

D. Submit report of test results.

E. Testing, checkout and start-up of the equipment shall be performed under the technical direction of the manufacturer's factory-trained representative. The drive system shall not be energized without authorization from the manufacturer's representative.

3.3 MANUFACTURER'S SERVICES

A. A factory trained representative shall be provided for installation supervision, start-up and test services and operation and maintenance personnel training services. The representative shall make a minimum of 4 visits to the site per pump with a minimum 4 hours on-site for each visit. The first visit shall be for assistance in the installation of equipment. Subsequent visits shall be for checking the completed installation, start-up and training of the system. Manufacturer's representative shall test operate the system in the presence of the ENGINEER and verify that the equipment conforms to the requirements. Representative shall revisit the Site as often as necessary until all trouble is corrected and the installation is entirely satisfactory.

B. All costs, including travel, lodging, meals and incidentals, for additional visits shall be at no additional cost to the OWNER.

++ END OF SECTION ++

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SECTION 46 43 73

TUBE SETTLERS

PART 1 - GENERAL

1.1 DESCRIPTION

A. Scope:
   1. CONTRACTOR shall furnish all labor, materials, equipment and incidentals required to provide, as shown and specified, a complete installation of the following at the North Sedimentation Basin and South Sedimentation Basin.
      a. Tube settler modules.
      b. Protective surface grating.

B. Responsibility: To ensure that all the equipment is properly coordinated, the CONTRACTOR shall obtain all the equipment specified herein from a single manufacturer. However, the CONTRACTOR shall retain ultimate responsibility under this Contract for equipment coordination, installation, operation and guarantee.

C. Coordination:
   1. Review installation procedures under other sections and coordinate with the Work which is related to this section.

D. Related Work Specified Elsewhere:
   1. Section 09 91 00, Painting.

1.2 QUALITY ASSURANCE

A. Reference Standards: Comply with applicable provisions and recommendations of the following, except as otherwise shown or specified.
   1. ASTM D 256, Impact Resistance of Plastics.
   2. ASTM D 570, Water Absorption of Plastics.
   3. ASTM D 638, Tensile Properties of Plastics.
   4. ASTM D 696, Coefficient of Linear Thermal Expansion of Plastics.
   5. ASTM D 790, Flexural Properties of Plastics.
   6. ASTM D 2583, Indentation Hardness of Plastics (Barcol).
   7. Standards of the Reinforced Plastic/Composites Institute.
   8. National Bureau of Standards, PS 15-69.
   9. ANSI/NSF-61.

B. Tube settler manufacturer shall have a minimum of ten years of continuous experience in the manufacture of tube settlers with a minimum of fifty United States

installations in service for a minimum of five years. At least ten installations shall include the protective surface grating.

1.3 SUBMITTALS

A. Shop Drawings and Product Data:
   1. Submit Shop Drawings showing the following:
      a. Submit detailed drawings showing the configuration of the tube settler modules and the manner in which they will be installed. The installation drawings shall include detailed instructions to the installer regarding any field trimming or other modifications to fit the modules to the sedimentation basins.
      b. Layout drawings and materials of construction for protective surface grating.
      c. Manufacturer's installation and recommended startup procedure.
      d. Load testing method and results.
      e. Manufacturer's guarantee for the minimum terms of the correction period in Section 00 73 01, SC-13.07.C.

B. Operation and Maintenance Data:
   1. Comply with the requirements of Section 01 78 23.
   2. Provide detailed tube settlers cleaning instructions.

C. Provide current certificate that tube settler modules and grating are tested and certified by ANSI/NSF to ANSI/NSF Standard 61 Drinking Water System Components.

PART 2 - PRODUCTS

2.1 SERVICE CONDITIONS

A. Description: Provide tube settler modules and protective surface grating at North Clarifier and South Clarifier.
   1. Characteristics of the existing basins are as follows:

Design Basis for the Tube Settler System Performance

	North Basin	South Basin
Max hydraulic flow rate	6 mgd	6 mgd
Loading rate at maximum flow	2.0 gal/min/sq. ft.	2.0 gal/min/sq. ft.
Minimum surface area	2000 sq. ft	2000 sq. ft.

Clarifier Dimensions	North Basin	South Basin
Width, ft.	65	65
Length, ft.	65	65
Side Water Depth, ft.	15.5	15.5

2. Field verify dimensions of each clarifier prior to providing product submittals. Basin dimensions may vary slightly from dimensions specified above. No extra compensation will be paid for minor variations from specified dimensions.

3. Tube settler modules shall be designed to maintain structural integrity under a loading of 15 pounds per sq. ft. which includes module dead weight plus a uniformly distributed solids load of 10 pounds per sq. ft. while supporting a movable live load of 250 pounds concentrated over a one sq. ft. area.

4. The system of tube settler modules shall be designed to maintain structural integrity under a loading of 15 pounds per sq. ft. which includes module dead weight plus a uniformly distributed solids load of 10 pounds per sq. ft. while supporting a movable live load of 500 pounds concentrated over a one sq. ft. area.

2.2 TUBE SETTLER MODULES

A. General:
   1. The area of new tube settlers shall be equivalent to the area of tube settlers being replaced.
   2. Tube settlers shall be composed of a multiplicity of uni-directional tube-like channels at least four square inches in cross-sectional area sloped from the horizontal. Tube settlers shall provide natural drainage of suspended solids. Modules shall be designed and arranged to provide the lowest practical Reynolds number for conditions of laminar flow.
   3. Effective settling height of the tubes shall be at least 24 inches, with a length of no more than 28 inches, inclined at 60 degrees from the horizontal.
   4. Tube settler modules shall be factory fabricated to the greatest extent possible to minimize field cutting.

B. Materials:
   1. Materials used in tube settler module construction shall be inert and resistant to deterioration from naturally present chemical constituents in the water supply

and from the proposed dosage rates of treatment chemicals added in the water treatment process and suitable for pH range of 4.5 to 9.0. Surface properties of the materials of construction shall prevent the accumulation of deposits to the extent that the intended function of the tube settler modules would be seriously impaired as measured by total plant performance.

2. Tube settler modules shall be built-up from evenly spaced sheets of rigid polyvinyl chloride (PVC) bonded together to form a durable structure. The PVC sheets shall be evenly spaced so that they form tube-like channels running from the bottom of the module to the top, inclined at 60 degrees from the horizontal. The tubes shall be molded of high-impact PVC with a minimum finished thickness of 20 mils plus/minus .002 inches. The PVC sheet shall be primed and rigid and contain UV stabilizers. It shall have a polished surface to minimize adherence of solids, and shall conform to commercial standards ANSI/ASTM D 1784-78; 12454B. Tubes constructed of ABS plastic shall not be allowed.
3. Solvent welding process shall provide a continuous bond between the various components of the module assembly. Finished bonds shall provide a rigid structure capable of resisting rupture under normal conditions of handling during installation and operation of the modules.
4. All fasteners and ties used in the installation of the tube settler modules shall be Type 304 Stainless Steel.
5. The material of construction shall be flame resistant, self extinguishing rigid PVC. Virgin material shall be used. Tube settler modules shall be blue or White in color. Tube settler modules must be tested and certified by ANSI/NSF to ANSI/NSF Standard 61. Current certification must be indelibly marked on sheets of modules.

2.3 PROTECTIVE SURFACE GRATING

A. General
   1. The protective surface grating shall provide a protective surface on top of the tube settler media to minimize hydraulic impact and provide operator access. The grating system shall be designed and provided by the tube settler manufacturer and shall be an integral component and regularly available option as part of their system. The protective surface grating shall be installed directly on top of the tubes without additional support structures.
   2. Grating shall comprise of multiple square mesh of 2 in. x 2 in. openings, molded together to provide a strong and lightweight panel. The height of the grating shall be a maximum of 1-1/4 inch.
   3. The grating system shall be designed to prevent damage to the tube settler media, and allow for ease of placement and removal.
   4. Protective surface grating shall be designed to maintain structural integrity under a loading of 15 pounds per sq. ft. which includes module dead weight plus a uniformly distributed solids load of 10 pounds per sq. ft. while supporting a movable live load of 250 pounds concentrated over a one sq. ft. area

B. Materials:

1. Materials used in protective surface grating construction shall be inert and resistant to deterioration from naturally present chemical constituents in the water supply and from the proposed dosage rates of treatment chemicals added in the water treatment process and suitable for pH range of 4.5 to 9.0.
2. Protective surface grating modules shall be constructed of HDPE or fiberglass and contain UV stabilizers.
3. The material of construction must be tested and certified by ANSI/NSF to ANSI/NSF Standard 61.

C. Installation:
1. Install surface grating in accordance with the manufacturer's instructions.
2. Grating shall be installed in panels side-by-side and placed on top of the tube settler media as shown on the plans and drawings for the project. Each panel shall be snapped together with the adjacent panel with locks provided at the edges of each panel.

2.5 MANUFACTURERS

A. Manufacturers:
1. Provide tube settlers and protective surface grating as manufactured by:
a. Brentwood Industries.
b. Enviropax

PART 3 - EXECUTION

3.1 DELIVERY, STORAGE & HANDLING

A. Delivery
1. Tube modules shall be shipped and delivered to job site on pallets.

B. Storage
1. All material and equipment shall be shipped, stored, handled, and installed in such a manner as to not degrade quality or serviceability.
2. The tube settling modules shall not be stacked more than four high (8 ft.) (one over the other).
3. All modules shall be stacked such that the PVC sheet planes are in a vertical position (similar to the manner of their placement inside the tank).
4. A light colored cover shall cover all modules required to be stored in the open beyond two months. Ideally these covers should be double sided such as a white on black. The white side, facing out, is used to reflect light away. Clear covers are prohibited. Black is not recommended. Black will absorb heat and if the cover comes in direct contact with the media, this heat can be quickly transferred to the media.

5. Covers cannot be wrapped tightly around the media. There should be at least a 6" air gap between the cover and top of media. The ends of the cover should be securely anchored on all sides with at least a 12" air gap at the bottom. These covers should provide shading while allowing air to pass through to prevent heat from building up.
6. Modules should be checked at least once a week. It is very possible that the covers can become loose over time due to wind or rain. A check of the stored area should be done to make any minor repairs to the cover or to restack any modules that could have fallen.

C. Handling
   1. Tube modules shall remain on shipping pallets until ready to install.
   2. Any abusive handling of the modules shall not be permitted. Workmen shall be careful in placing the tube modules and avoid any damage to the corners and tube edges.
   3. Personnel shall not stand or walk directly on top of the modules.
   4. Media modules may get brittle at low temperatures or soft at high temperatures. Therefore, care should be used in the handling of modules.

3.2 INSTALLATION

A. General:
   1. Remove existing tube settlers to the limits indicated in the Contract Drawings. Dispose of removed material in accordance with local regulations.
   2. Installation shall be in complete accordance with manufacturer's instructions.
   3. Check and align all other components of the equipment as required.

B. Tube Settler Supports:
   1. Existing support beams and support brackets shall be power washed to remove existing surface scale/tuberculation.

C. Installation:
   1. Install tube modules in accordance with the manufacturer's instructions.
   2. Install tube modules over the support system required and shown.
   3. Exercise care in placing the modules, with particular attention to the edges and corners. Do not handle or prod with sharp objects. Protect the modules from environmental extremes and from welding sparks or open flames.

   4. To access the tube settler surface, place a minimum of a 4' X 4' x 3/8" thick plywood sheets or protective surface grating on top of modules. The sheeting/grating is required to prevent damage to the tube settler edges and to distribute the weight of the worker. A potential safety hazard may occur if the

sheeting/grating is not utilized when walking atop the tube settlers. Do not stand or walk directly on top of the modules.

5. Top of adjacent tube modules shall be installed true level, with a tolerance of plus or minus 1/2 inch in full length.
6. Modules to be installed as closely as possible to minimize space between them with a maximum ½" allowed.
7. Cross corrugation of tubes with mixing points within individual modules is not allowed.
8. Replace all modules that have been damaged during fabrication, shipping, storage and installation.
9. Modules shall be cut to fit at the structural supports for locations as may be required. Cutting shall be done in accordance with manufacturer's recommendations.
10. The tube settling modules shall not be stacked more than four high (8 ft.) (one over the other). Modules shall be stacked such that the PVC sheet planes are in a vertical position (similar to the manner of their placement inside the tank).

3.3 START-UP

A. Make adjustments as required to place systems in proper operating condition.

B. Prior to installation, the CONTRACTOR shall provide the services of a manufacturer's representative for two (2) days to visit the job site to instruct the CONTRACTOR on installation methods, including cutting of the modules. Additional on-site services shall be provided as often as necessary to correct any trouble during installation. Such services shall be provided until the installation is entirely satisfactory to the OWNER/ENGINEER.

3.4 INSTRUCTION OF OPERATIONS AND MAINTENANCE PERSONNEL

A. Comply with Section 01 79 23, Instruction of Operations and Maintenance Personnel.

B. Instruction Course: After equipment is fully operational, and before OWNER will assume responsibility for the operation of equipment, the equipment manufacturer's operating specialists shall be on site for one (1) day to instruct the OWNER's operating personnel in the care, maintenance and proper operation of the equipment. Training shall include cleaning of the tubes and recommended personal protection equipment needed for cleaning.

C. All training sessions may be video-taped by OWNER.

++ END OF SECTION ++